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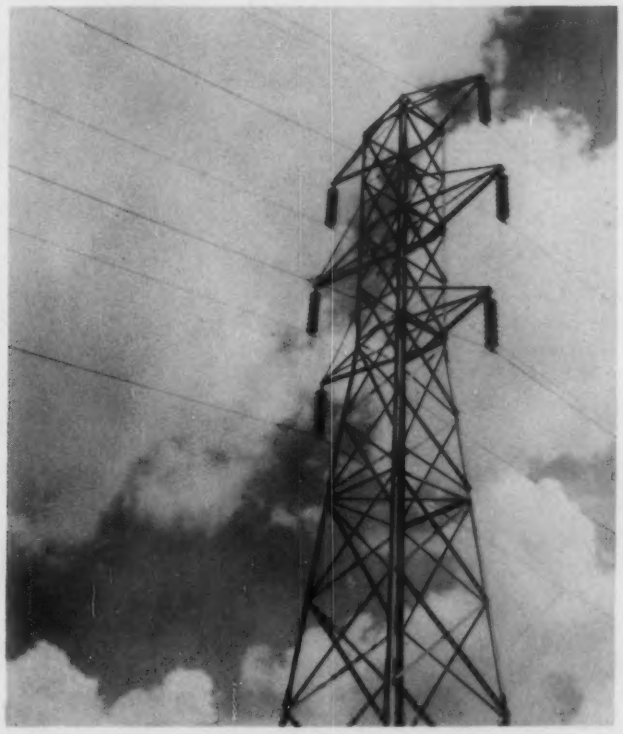
THE TECH ENGINEERING NEWS

DECEMBER · 1941



OUR COVER THIS MONTH
The stator yoke of a 38,889 KVA water wheel generator on a special tilting table designed to facilitate welding.
Allis-Chalmers Electrical Review

VOLUME XXII
NUMBER 7

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WHAT'S AHEAD?

A PREVIEW OF WHAT ELECTRICITY MAY BE DOING FOR US IN 1951

By PROF. HAROLD L. HAZEN

HEAD OF ELECTRICAL ENGINEERING DEPARTMENT, M. I. T.

BEFORE projecting his line ahead by a foresight, the surveyor takes a backsight for orientation. As a backsight for a look ahead in electrical engineering, suppose we picture to ourselves the reactions of a man like Lord Kelvin, who was actively contributing to electrical science during the last half of last century, were he to have gone to sleep in 1881 and awakened unchanged in 1941. During his six decades' nap our entire electric power technique and industry have been created, our vast electrical-communications complex has developed from the fair telegraph of his day and the five-year-old telephone including a then radically new "long-distance" line from Boston to Providence, while the radio and the electronic science and art have appeared in their entirety.

We may be sure that Kelvin's reaction would be merely that he had somehow dropped behind in his technical reading and that his practical engineering vocabulary was out of date. From his analysis of the submarine cable in 1854, he would find it but a few steps to the extensive communications and power-line theory of today, steps adding greatly to the art but readily fitting into his knowledge. The electron he would welcome as an object for which he had long sought in his speculations on the nature of the atom. His friend, James Clerk Maxwell, who died in 1879, had shown him in mathematical detail the fundamental nature of radio waves, though they had not yet been observed experimentally. Coming nearer home, he would instantly recognize in our differential analyzer the physical embodiment of the machine whose underlying mechanical and mathematical concepts he had stated with such beautiful clarity in 1876. Such are but typical examples of how the vast electrical art of 1941 is in surprisingly large measure the practical manifestation of science Kelvin had mastered and taught to his students by 1881. Thus we could reasonably expect that, within a few months after his awakening, Lord Kelvin would have largely caught up with the technical times — and would probably already have been giving stiff competition to the moderns — because the underlying science and the mathematical tools of which he was master are in most essential respects those of today despite the almost complete metamorphosis and enormous growth of the electrical art meanwhile. Surely if on awakening Kelvin could in this reasonable time catch up with the cataclysmic developments of these six decades, the student should have no serious worries about the adequacy of his present preparation for responsible work in 1951.

Opposite page . . . ***Inspecting the expansion tank of one of a bank of four 12,500 KVA power transformers***
Allis-Chalmers Electrical Review

Our picture of Kelvin's ready adjustment to sixty years' unprecedented creations is a striking confirmation of the fundamental continuity of scientific evolution, and of the enduring value of the stern discipline of scientific training. As the engineering undergraduate of today looks a decade, or even four decades, ahead, he may be well assured that a rigorous mastery of underlying principles and hard analytical thought will prepare him to grow with and contribute to new art, though we do not now know what it will be. But let us try to see what may lie ahead by looking (necessarily very sketchily) at some past developments — current accomplishments, present frontiers, unanswered needs — and then let our imaginations play a little. In this way we can perhaps get some glimpses of what you who are now in school will be doing after you have become reasonably well established in your profession.

For examining electrical developments with a view to taking our decade foresight, it is convenient to separate the field functionally into the three major divisions of power, communications, and utilization, though the boundaries between these are seldom sharp. Under "power" are included the large-scale generation, transmission, distribution, and "consumption" of electrical energy. Here the object is to deliver sizeable quantities of energy to the ultimate user at a minimum unit cost, implying relatively high efficiency of handling. In communications, in contrast, the commodity conveyed is intelligence or information in some form. The energies involved are in general small, since the recipient cares for only enough to register an accurate impression on one of his senses. Minimum cost per unit of received intelligence is the criterion of merit, which usually dictates a vanishingly small energy efficiency of transmission. Under "utilization," for want of a more satisfactory word, is included the multitude of important uses of electrical agencies to perform useful tasks. Therapeutic x-ray apparatus, photoelectric bean sorters, means for measuring almost any kind of measurable quantity, and some not so measurable — witness the glamor meters devised by zealous embryonic engineers for the calibration of their dance "dates" — all come in this miscellaneous but most significant category.

Ten years hence the "power" field may well look different from that of today only in details, some far from trivial to be sure, but with the major features familiar. Investments of several dollars in plant per annual gross revenue dollar and stringent governmental regulation, coupled with relatively high efficiencies of existing apparatus — excepting the fuel-to-mechanical-energy conversion — tend toward low rates of obsolescence in the power industry. Substantial refinements will unquestionably continue; new turbo alternators are

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Winding a high voltage coil of a 40,000 KVA, 230,000 volt, water-cooled transformer built for Bonneville project

shifting rapidly from 1800 rpm to the smaller 3600 rpm machines; hydrogen cooling is now here for large units; circuit breakers which are something different from a potential spark plug in a tank car of oil are now commercially acceptable. Lightning protection, now reasonably adequate, has required a decade or two for its development on many fronts, and is still a most active field for investigation. Large power rectifiers have undergone their major development in this country during the last decade or two, and this subject is still very much alive. These statements apply as well to high-voltage power cables.

Long-distance high-voltage direct-current transmission may become important during the next decade for new projects, especially if cessation of wars permits major peace-time activities for development engineers. Wind and tide are almost ready to yield their power commercially. Much more speculative are the possibilities of efficiently securing electrical energy directly from burning fuels and from the sun's radiant energy. Here are needed new fundamental discoveries which the coming decade may or may not bring forth. In a similar category is a low-cost storage battery having, say, ten times the present energy storage capacity per unit weight, or a material having ten times the electrical conductivity of copper. Any one of these or of many other discoveries could have a revolutionary effect upon large areas of electrical engineering. Any such discovery is likely to be in a form that on its face has no connection with its ultimate application and may lie dormant until some unconventional scientist or engineer sees the connection.

In the power field, therefore, the electrical engineer can reasonably expect a consistent development and improvement of known art, punctuated by occasional significant infusions of new art, with perhaps a rare revolutionary change. Even the consistent steady advances, however, require large amounts of engineering talent of high quality and provide fascinating problems for solution at every stage. Heavy power manufacturing and the power utilities serve a basic need in our industrial civilization and will unquestionably continue to require substantial numbers of new technical men over any given span of years. Numerous names of recent graduates appear as authors in the power field in the *1940 Transactions of the American Institute of Electrical Engineers.*

Electrical communications broadly defined represents a very wide field. The reproduction of symbols, sounds, and pictures at a distance, using wire or free space transmission or both, is obviously part of it, involving a multitude of specialized equipments such as: for symbols, the wire, submarine cable and wireless telegraphs, teletype, telautograph; for sounds, the telephone, radio, public-address system, the sound-reproduction systems of talking moving pictures and of magnetic and mechanical recordings; for pictures, facsimile transmission and television, to cite some typical examples. Perhaps less obviously yet quite as reasonably considered a part of electrical communications, are systems for providing data at a distance, for they require similar techniques. These systems are a multitude in form and are illustrated by railway signals, remote metering systems, radio ranges and direction

finders, airplane radio instrument landing systems, electrical altitude meters and water depth meters, obstacle detectors, and other electrical means for determining the relative positions of two points or objects. Diverse as the functions of these systems appear, the underlying techniques are surprisingly similar; in fact, they constitute substantially one art containing numerous specialties. Hence, in glancing at past and present developments, we should look at the art as a whole, quite as much as at the functional specialties, even though the developments of functional specialties may be the conspicuous thing at any given time. For example, television — very prominent at present — is in good measure based on knowledge dicovered decades ago. Some of the problems in applying this knowledge in television have been very difficult, so that their solution has become virtually new art.

Along with television, frequency-modulated radio telephony is a conspicuous current development of a conception investigated mathematically twenty years ago. Probably most significant, however, are the rapid strides being made in ultra-high-frequency radio, in which vast numbers of new channels in the otherwise badly crowded "ether" are being made available. For example, there is, theoretically at least, room for the entire broadcast band between 3000 and 3001 megacycles per second, or in terms of wavelength, between 9.997 and 10.000 centimeters. Ultra-high-frequency has another important characteristic by a fundamental law of radiating systems (such as antennas) that the directivity of a sender or receiver can be great only as the radiator becomes large with respect to the wavelength. Thus the practicability of high-directivity radiating systems or antennas at a 10-centimeter wavelength is of entirely different order from that at even 10 meters (30 megacycles per second), which was regarded as a very high frequency but a few years ago. Ultra-high-frequency is a vast, almost virgin field in which only the first explorations are now being made. The entire art of measuring ultra-high-frequency phenomena, for example, is about as advanced as was the art of measuring direct-current phenomena when these were being compared by the deflections of a compass needle surrounded by a few turns of wire carrying current.

In telephony and telegraphy by wire, the art is much more nearly mature, though still actively growing. The coaxial cable, a single conductor held centrally in a quarter-inch tube by occasional insulating spacer washers, and capable of carrying hundreds of simultaneous telephone conversations, is only now entering limited commercial application. Its potentialities could be realized, however, only by major developments in amplifier and filter or electrical sorting circuits. In another aspect of telephone art — that of machine switching for dial systems — the third major system to be used, called cross-bar switching, is now entering commercial use after extended development. For the future, replacement of mechanical switching by electronic switching offers opportunities for those of original mind. Radio, in both the broadcast and the commercial traffic phases, is like the telephone art in being an established and going industry but, being younger, has probably more significant developments yet to come; witness frequency modulation. Also none of us has yet heard the perfect broadcast reception or the perfect phonograph reproduction.

In communications, therefore, a vast amount of engineering is required, ranging from plant planning and the operation of telephone systems with its requirements of technical competence, good economic sense, and often diplomatic skill, to highly technical ultra-high-frequency developments in which fairly advanced physics is often required. Here the recent graduate's untarnished theory currently pushes him into engineering responsibility at breath-taking speed.

Our third subdivision of electrical engineering — utilization — is very large, yet because of its heterogeneity fails to make the popular impression that a Boulder Dam installation or a television system does. Electrical energy is extremely versatile. It can be readily and efficiently converted into mechanical work; into electromagnetic radiation throughout the entire known spectrum from X-rays through the ultraviolet, visible, infrared and heat regions, to the longest radio waves; into sound; into chemical energy; in fact, into an indication of almost any measurable physical quantity. Despite its intangibility, it and its characteristics are probably the most readily measured physical quantities known. Electrical energy is also very readily controlled in a great variety of ways in response to many types of stimulus. For example, besides electrical quantities, heat, light, sound, position, pressure, are all readily made to actuate electrical circuits in a quantitative and predictable way. Furthermore the electrical responses are so rapid with respect to the phenomena causing them that the time delays in the electrical responses can usually be neglected.

One further and extremely significant attribute of electricity is the tremendous and precise magnification or amplification that is practically obtainable by means of the vacuum tube. In commercial transcontinental telephony, for example, the total energy magnification employed is a number so large that the editor refused to print it out, but it is roughly 10^{100} times, that is, one followed by one hundred zeros. Yet we would object to the quality of service if this magnification were not done with a precision adequate for us to recognize unmistakably the voice at the distant end whenever we chose to call. This is merely typical, not extreme, for if the call spanned in addition to a continent the several thousand miles of ocean to Australia, we should have to add another twenty-five zeros to the foregoing figure in order to obtain the over-all energy magnification.

It is not at all strange, therefore, that throughout industry — through from the steel mills to the town garage, as well as in the research laboratory — an electrical meter usually tells the (*Continued on page 178*)

Electrically welding a large casting for a steam turbine

Allis-Chalmers Electrical Review

Crown Zellerbach Corp.

THE PULP AND PAPER INDUSTRY IN THE NATIONAL DEFENSE PROGRAM

By ALEXANDER HERON

CROWN ZELLERBACH CORPORATION

A DRAMATIC story is unfolding in a hundred items in our daily papers. A front page headline on one day, a short story on an inside page another day, an interview with a government official or a prominent manufacturer or labor union officer; unrelated subjects, apparently, but they fit together to form the biggest mosaic picture ever seen by human eyes.

National Campaign to Salvage Waste Paper. Ban on Residential Building. Installment Buying Restricted. Shortage of Bobby Pins and Zippers. Electric Refrigerators Made with Substitutes for Copper and Aluminum. Naval officers will do without swords because of shortages of metals. An insecticide spray-gun company switches to making parts for bombers. A manufacturer of animal traps is turning out army cots instead; a toy train company is making ships' compasses; an ash-tray plant is stamping out airplane parts from aluminum. Harbor Warehouse Space Requisitioned by Government. Women Rush to Buy Silk Stockings. Auto Production Cut Forty Per Cent.

What does it all mean? Simply that, in the broad public interest, industries are making radical readjustments, that certain basic materials have been earmarked as vital for defense or lend-lease activities; and that paper, steel, aluminum, copper, and many other commodities we have taken for granted in our peacetime economy have been drafted or have enlisted for the duration of the emergency.

No other American industrial product affects our daily lives as strongly and as continuously as paper in its many forms. A book could be written about the daily uses and benefits we enjoy because the processes of pulp and paper manufacture are going on, day and night. In five hundred primary mills and several times that number of secondary or converting plants, nearly four hundred thousand workers are preparing for us the products we use every day. Any casual observer can list, in thirty minutes, nearly a hundred uses of paper products.

But like the electric current which lights our homes, offices, and streets, paper serves our constant need so casually that few of us know or care whence it comes or how. Millions of us are scheduled to learn surprising things about paper in the next few months because paper has enlisted in the National Defense Program.

While we cannot think of the pulp and paper industry as a primary defense factor such as the airplane plants and shipyards, it is an industry destined to play a part which is indispensable, and to experience dislocation and readjustment of a major kind. We shall learn things about this industry because our daily conveniences are about to be reduced. Paper has enlisted!

We may begin to prepare ourselves for these new

realizations by considering paper much as we consider the neighbor boy next door who has been inducted into the military service. We are not recalling his habits of singing in the bath tub and racing the engine of his jalopy in the driveway, the fact that he took care of our lawn on Saturday afternoon and usually washed the car for us, or that he kept a light burning late opposite our room while he really studied during his last year in college. Of course we could think of these everyday facts, but what we think and ask will be something like this: "To what camp has he gone? What branch of the service? What kind of training is he receiving? What is he doing?"

If paper has enlisted, what is it doing in the Defense Program?

One typical service of paper in the Defense Program is reflected in the initial steps by which the Selective Service Act was put into operation. The processes of announcing and organizing the program, registering, tabulating, and originally classifying the eligible men, probably consumed 800,000,000 sheets of paper, or about 4,000 tons. This paper was not purchased from the shelves or warehouses of paper dealers. It was almost necessarily ordered to meet definite specifications for this particular job. It enlisted the services of thousands of men in scores of successive operations, from the forests to the railroad delivery platform.

Another homely and common service is typified by the fact that the United States Army has required the annual manufacture of 8,000 tons of paper laundry bags for the use of men, like the boy next door, who have gone into the military service. On this account, some manufacturers had to change their normal programs and take the necessary steps to make the required pulp, make the paper of the required quality, weight, and color, and form the laundry bags to meet this incidental but important need of the Defense Program.

These services, which are very much like the ones paper has been doing for us in our everyday civilian lives, have many parallels in the Defense Program. Incredible quantities of paper towels and toilet tissues for the Army and Navy, cement bags for construction contractors building cantonments, cannon emplacements and hundreds of other structures, insulating paper for both temporary and permanent construction jobs, printing paper for instructions, reports and forms without number — these are services for the Defense Program. Many of them have required the partial elimination of similar services for civilian needs. Engineers, architects, draftsmen, and technical students have some knowledge of consumption of drafting paper, tracing paper, and blueprint paper. Many of them know that such papers today are difficult to obtain through the ordinary commercial channels. Someone has offered as a partial explanation the estimate that forty tons of blueprint paper are used in preparing for the construction of a battleship. Here, again, paper has enlisted in the National Defense effort. It must serve this function or there will be no two-ocean Navy. We shall miss the ample supplies of wrapping paper that we took for granted just as we took for granted the boy next door.

Aid to the democracies is a large part of the present defense effort of the United States. A large part of this aid consists of supplying subsistence materials to both civilian and military personnel in the nations which are resisting the Nazi invasions. As a specific example, food for Britain is rated as one of the first essentials in the defense of democracy.

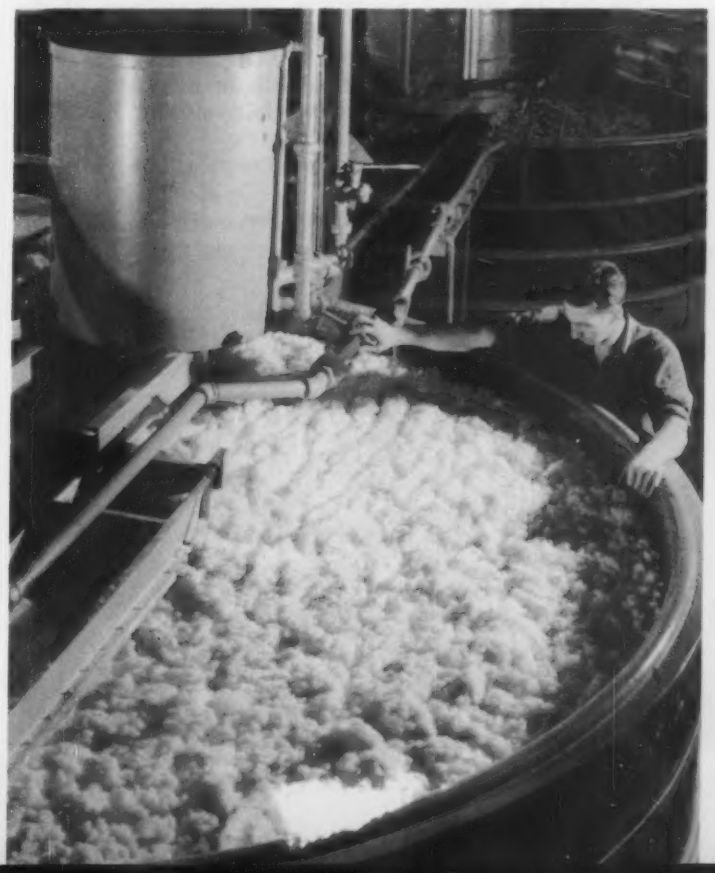
Food for Britain cannot be shipped in barrels, boxes, or burlap bags; for one reason, these containers are not available; for another reason, shipping space must be conserved by every means, especially avoiding excess bulk and weight. The Defense Program, therefore, has drafted another product of the paper industry, the fibre or corrugated board container. Fresh food, dried foods, canned foods, foods of every description are moving across the Atlantic in fibre containers produced by the American paper industry. In this other typical product field, the paperboard industry is required to curtail its service to the ordinary civilian needs so as to give the necessary service to the Defense Program.

Tomatoes from North America are an essential item in the diet of the British population. In fact, the British are extremely anxious to have a huge supply in reserve in case bombing or shellfire destroys their domestic water supply reservoirs and pipelines. The demand for tomatoes for the Defense Program this year will probably be greater than the total production of tomatoes last year. From the sprouting of the seed to the delivery of the finished product, paper contributes to a larger and better crop. Protective covers for the seedling plants, sturdy wind shelters for the growing plants, and preservative wrappers and paperboard containers for the mature tomatoes are just a few of the products required of paper.

The preservative wraps are significant in scores of fruit and vegetable products other than tomatoes. We have often seen the attractive tissue wrap in which are packed our oranges, apples, pears and similar fruits. Probably most of us have taken for granted that its principal value was in the label or the advertising. In most cases the real value is in a very complex chemical treatment of the paper which protects and preserves the fruit against various dangers of disease and decay. In all such wraps, there is the protection against bruising and friction. In the drying of small fruits, particularly raisins, a specially prepared and processed paper known as "raisin tray" is required. This year the Defense Program has drafted the paper industry to supply unprecedented quantities of this material.

A few paper mills have been able, during past years, to supply a special quality of paper used for the wrapping of agricultural explosives. This type of paper,

Pulp-beating operation *Crown Zellerbach Corp.*



known as "cartridge manila", has a parallel and infinitely greater use in the manufacture and delivery of explosives for the military and naval services. As a typical instance, one small paper mill has been required to set aside much of its production of ordinary civilian papers and convert the major part of its facilities to the production of cartridge manila for the Defense Program.

Another of the enlistments represents an active contribution by the pulp industry, an integral part of the industry; it also represents a definite and necessary sacrifice by the paper-making industry in particular. For many months, pulp made from wood by the chemical process has been an important item in the Lease-Lend Program. This wood pulp, refined to such an extent that it provides nearly pure cellulose, is the basis of the manufacture of certain important explosives. It is not needed in normal times when the alternative supply from cotton linters is plentiful, but now the armed forces of the democracies are calling for more and more of this wood pulp cellulose. The pulp industry is thus enlisted in the Defense Program, and the paper industry is thus deprived of much of its ordinary manufacturing material.

The finest of the chemical wood pulps of this type is the raw material for most of our rayon. The pulp industry, through its outlet in the rayon industry, is enlisted in the Defense Program in ways which are dramatic and surprising. From the pulp mills, through the rayon mills and spinning mills, a special rayon cord is delivered to the rubber manufacturer and eventually does its part in the Defense Program by contributing strength and body to the gigantic tires of airplanes of every type. The gigantic bomber makes its landing on super tires which must be durable and reliable to the highest degree. The pulp industry has contributed the material for the rayon cords which furnish the fabric for many of these tires.

The variety of ways in which chemical wood pulp, processed into rayon, serves in the Defense Program makes a long list in themselves. Fabric for parachutes or for the chevrons on the corporal's sleeve, staple fibre for articles of clothing, and many other final forms will be on the list.

Similarly, differently processed pulps furnish the bases for plastics. It is not necessary even to start the list of uses of plastics in various phases of the Defense Program. Here again the pulp division of the paper industry is enlisted in the Defense Program.

The positive side of this enlistment could not be covered by anything less than a full volume. But there is also a negative side.

Like every good citizen of America, the pulp and paper industry is undergoing handicaps and hardships as a necessary part of the Defense Program. Its personnel has been depleted by the needs of the military establishment, which has taken thousands of skillful young men. Even more seriously, many of its most skilled mechanics have left this industry to go to the defense industries where their particular skills are more urgently needed. Machinists, millwrights, welders, electricians, and many other craftsmen have been called from the paper industry to meet the urgent needs of shipyards, airplane factories, engine plants, and other direct defense producers. Experienced executives and supervisors from the pulp and paper industry have been called into the service of the War Department, the Navy Department, and the Office of Production Management.

The pulp and paper industry is likewise performing like a good citizen in foregoing the supply of some of its most essential materials and equipment. The Defense Program has solicited and obtained from the industry approximately a forty per cent reduction in the use of chlorine. This may not sound like a sacrifice; but with further curtailment of this single item, the average citizen will find it more and more difficult to buy the pure white papers to which he is accustomed, papers made white by the bleaching process based on chlorine.

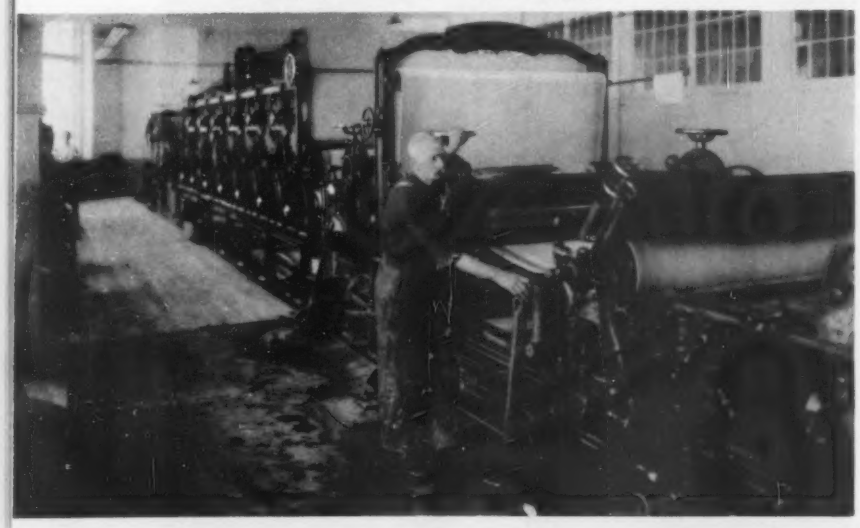
A scarcity of copper threatens the supply of the highly specialized wire meshes which the industry uses in the form of Fourdrinier wires and cylinder covers. Without these wires, paper cannot be formed. There may be paper mills closed and paper mill workers unemployed because of the more urgent defense demands for the limited supply of copper available.

Similar sacrifices are being faced by the industry in hundreds of other needs. From babbitt metal for bearings, acid resisting metal for its pumps and pipes, and electric power supplies, to highly essential processed chemicals, the pulp and paper industry is being enlisted to sacrifice for the Defense Program. All its resourcefulness will be devoted to finding substitutes, or getting along without. Eventually, the limit of makeshift arrangements will be reached, and some producing units will cease to operate.

Pulp and paper mills, as a part of their enlistment requirements, have well-equipped mechanical shops of various kinds. Throughout the country many of these shops have been placed at the disposal of the defense training program. Young men are receiving practical and intensive training in the use of the equipment, and are acquiring the preliminary skills, so that in time they will move promptly to fill the urgent needs of rapidly expanding defense industries.

As a corollary to these adjustments, you and I, in our everyday lives, will become conscious of the importance of paper products when we can no longer get them. We shall be conscious of the fine qualities which we have received and expected, and when these qualities are no longer available, we shall realize dimly that this taken-for-granted supply of paper and paper products was highly important in our everyday affairs. Because of this realization, we shall be able to visualize its corresponding and even greater importance as an element in the Defense Program of our nation.

Drying cylinders of a modern paper machine *Dard Hunter*



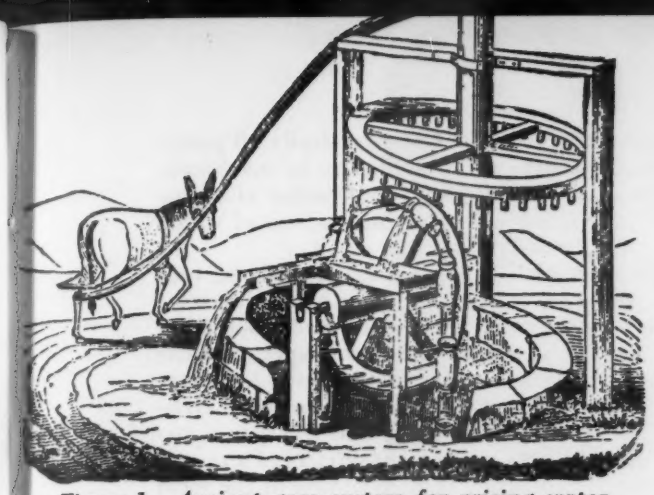


Figure 1. Ancient gear system for raising water

GEARS MEAN PROGRESS

THE STORY OF GEARING IS THE STORY OF INDUSTRIAL DEVELOPMENT

By S. M. RANSOME
CHIEF ENGINEER, BARBER-COLEMAN CO.

THE subject of gearing is an extremely broad one, whether measured by the extent of its modern uses and applications or by looking backward over the pages of history. It is impossible to treat all aspects of the subject, yet in this article we will endeavor to trace the progress of gearing from its rudimentary beginnings to its present highly developed state.

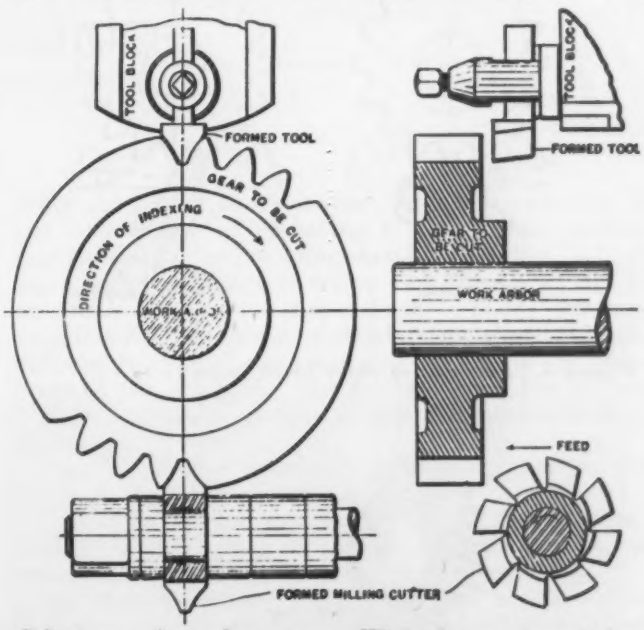
One might say that the state of civilization which any particular nation has attained could be determined quite readily by a study of its gearing. Gearing, considered historically, can be found in the earliest and most elementary machines known; and its development has kept pace with scientific and mechanical developments through the centuries. One of the reasons for studying some of the earlier types of gearing is to provide a background to show up more clearly the tremendous advances which have been made, and to accentuate the extremely refined degree of accuracy which has been attained in the manufacture of modern gears.

Figure 1 shows an example of probably one of the earliest types of gearing ever used. It is of ancient Roman origin and of unknown antiquity. The illustration shows a power-driven set of bevel gears undoubtedly made of wood throughout and used in the raising of water by a wheel and chain with buckets. This mechanism with its continuous rotary motion shows a considerable advance over still earlier methods devised for doing this same work. It is interesting to note that the raising of water from a well seems to have been the place where power devices of various kinds were first applied, at least to any great extent, the early Chinese, Hindus, and Egyptians all having certain types of what might be called mechanisms for this purpose.

The pin idea for gearing existed for probably two thousand years, although the gears became smaller and the uses much more varied. About two thousand years ago the metal gear was first employed. A further development of the pin gear was the lantern wheel with rods arranged between two disks in the form of a cage. This type is commonly used in modern clocks, there being a special tooth gear designed to run with the lantern wheel or pinion. This construction, however, seems to have been fairly well confined to the clock-making industry, as it is evidently not satisfactory for hard or severe service.

Probably following the use of pin gears would come the use of gears having roughly shaped teeth cut from

Figure 2. Formed tool method of gear cutting



solid pieces of wood or stone. With the coming of the iron age, cast gears were introduced. These early cast gears were made, as the title indicated, by molding or casting. That is, a wooden pattern was shaped, usually by a pattern maker, and the gears were cast with the teeth integral, teeth being afterwards roughly ground or filed to remove the greater irregularities. Gears were then, as far as the teeth were concerned, ready for use.

It might be mentioned that this type of cast gear was still in general use up to a period of fifty or sixty years ago, and was used in such applications as back gears for lathes, gears for shapers, planers, and other machine tools. The greatest objection to such gears was that they could be used only for relatively slow pitch line velocities because of their excessive noise and vibration.

As just mentioned, one of the chief objections to cast gears was their excessive noise, and it was soon found that this could be readily overcome by the use of a mating gear having wooden teeth, usually of beech or hard maple. These teeth were mortised into a rim, and then wedged in position. They were shaped with a chisel by a pattern maker working from a template, or, in later practice, by a special machine with a power-driven saw. These gears were largely used in such installations as flour mill drives.

As both the public and industry began to demand and expect increasing speed in gearing together with the smallest possible size for gears, it became evident that cast gears, even when mated with wooden gears, were rapidly becoming inadequate. About fifty years ago we entered into a period where practically all gears, especially smaller gears, were required to be machined. Quite a number of methods appeared rather close together, some of which are obsolete and others of which are in use to the present time.

Figure 2 shows what is known as the formed tool method which divides itself, as shown in the diagram, into two subdivisions: one using a formed tool of a single point construction in a planer or shaper, and the other using a formed cutter. The latter method of manufacture is in use to the present day. It has been elaborated into the well-known Brown and Sharpe eight-cutter system, whereby a set of eight cutters of any one pitch are used to produce an approximation of the form required for the gear. For example, cutter No. 8 would produce a gear of from 12 to 13 teeth and cutter No. 1 would form over 135 teeth per gear. Later on, these eight cutters were found to be insufficient and seven intermediate cutters known as Nos. 1½, 2½, etc. were introduced to give closer approximation of the gear tooth form.

The template method, in which the cutting tool follows the shape of a master gear, was used but is now largely obsolete. Another practically obsolete method was the odontographic method, developed by the famous gear engineer, Mr. Grant. It produced gears in a circular arc form, this arc being determined by formulae to give as close an approximation as possible to an involute form. Gears have been generated by rolling, although this method is limited by the difficulty in obtaining materials soft enough to be pressed into shape by a master gear. This method has been successfully employed using a red-hot steel blank and a hardened steel-forming gear. The same method using a reciprocating cutter for the formed gear is used extensively today. Gears may be machined quite rapidly from the blank by this system.

Figure 3 shows a group of other methods of producing gears by generating, all methods being used to some extent today. The application (*Continued on page 174*)

Figure 3
Four early methods of generating and finishing gears

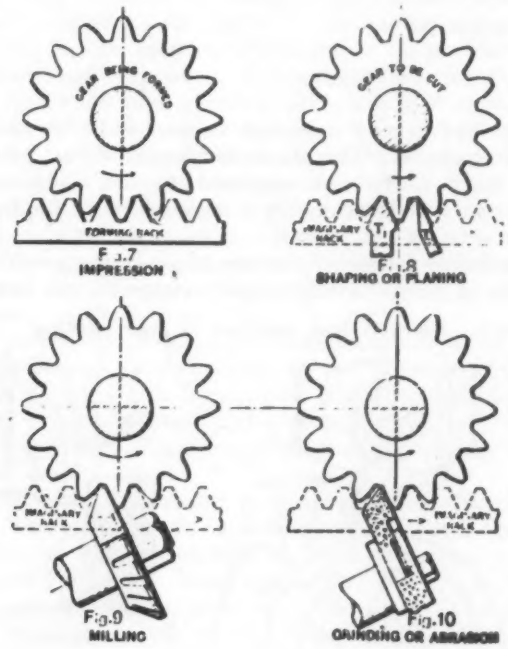


Figure 4. Example of skew bevel gears

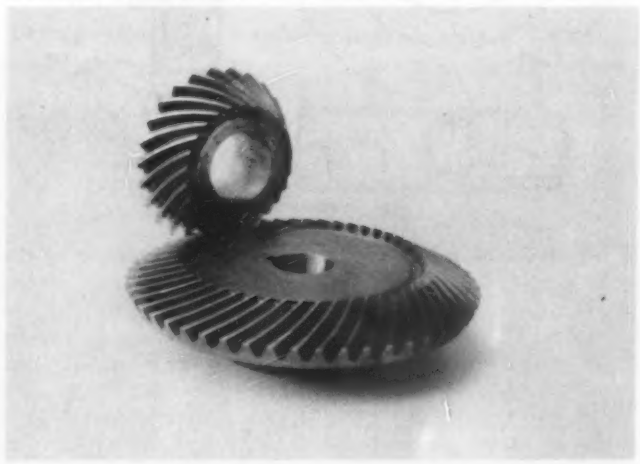
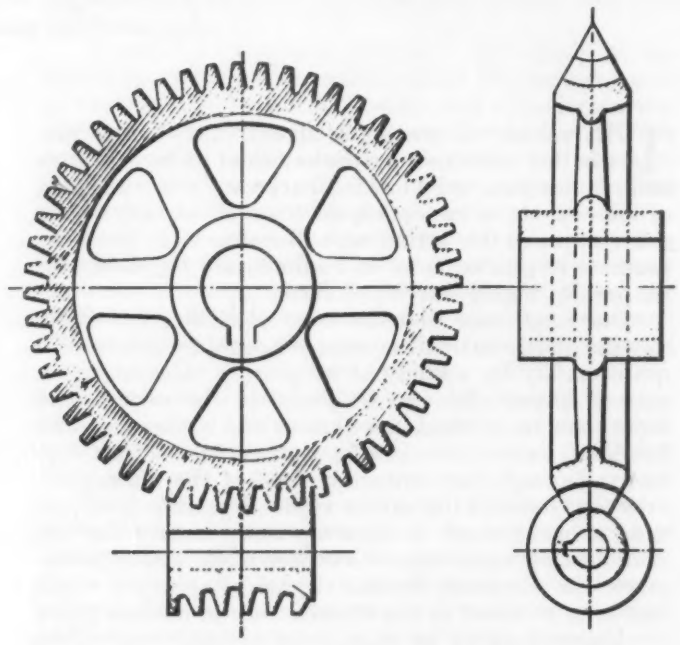


Figure 5
Diagram of hourglass type of worm and worm gear



NEW RUBBER FOR OLD

THE RECLAMATION OF USED RUBBER IS A VITAL DEFENSE INDUSTRY

By R. W. MOORHOUSE

MANAGER OF CHEMICAL ENGINEERING DIVISION,
GOODYEAR TIRE AND RUBBER COMPANY

THE basic process on which is built the rubber industry of today is vulcanization. By this process, soft, plastic raw or crude rubber, after admixture of selected compounding materials, is transformed, usually by heat, into the dry, elastic form known to all of us.

The elastic or cured form can be deformed by external force, resuming to a large degree its original shape on removal of the force. Sufficient force causes failure, and eventually disintegration of the article. It is impossible, then, to return cured rubber goods to the mixing and shaping operations carried out in preparing crude rubber for the final cure. Any spoilage in process is therefore "scrape" or waste.

Complete destruction of rubber goods in use seldom if ever occurs. The accumulation of worn-out rubber articles and the losses in "scrap" during manufacture have long suffered a fertile field if a process could be derived to return to the cured, elastic rubber its original plastic form, so that it again could be used in the manufacture of rubber goods. Attempts to reclaim rubber date back almost as far as the discovery by Charles Goodyear in 1839 of successful vulcanization.

The growth of the rubber industry after 1900 gave impetus to these attempts, and very shortly commercial reclaiming processes came into use. The hope of recovering the rubber in its original, raw state gave way to the compromise of obtaining a soft, plastic product containing the compounding materials originally added, but controlled in the selection and process to supply an article of value to the industry. Today we have available literally scores of standard reclaimed rubbers, differing in type of scrap and process, and in the properties of the "reclaims" themselves. Each has its use.

The successful processes may be classed in four groups, as follows:

(*a*) Mechanical processes. — Disintegration in the presence of softening agents and heat.

(*b*) Open steam processes. — Steam under controlled pressure acting directly on ground scrap in the presence of softening and penetrating agents.

(*c*) Acid processes. — Mineral acids, hot, are used to destroy the fabric in the scrap, and to produce a line of special reclaims.

(*d*) Alkali processes. — Alkaline liquors, hot, under pressure, usually with softening agents, destroy the fabric in the scrap and produce a line of reclaims forming the bulk of the output.

Each of the above processes has a particular use, dictated by the type of product desired, the allowable finished cost and the available scrap. The most common form of scrap is the (*Continued on page 182*)

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FRANKLY SPEAKING . .

THE TECHNOLOGY STUDENT

It has come to the attention of this magazine that very little is known about the average Tech student or his life during his stay at the Institute. No one person or group of persons has an accurate picture of how the student spends his time. Until such a picture is obtained, every new development pertaining to the general well-being of the student body is a shot in the dark. When there is a definite point of friction in student life, the faculty and administration of the Institute wish to alleviate the situation. However, it is, at present, largely a question as to exactly how to go about it. This might very possibly stem from a lack of knowledge regarding the general habits of the average student.

With this in mind, The Tech Engineering News, with the help of the faculty and administration, have prepared a survey. This survey, it is felt, is quite complete in question material, and if answered honestly and to the best of the ability of the questionee should provide a good basis for future considerations of student life at Technology. There is at present a Visiting Committee on Student Affairs which has in its hands the development of new extracurricular facilities at the Institute. It is felt that this survey will prove of value to the committee.

This is then the reason for the survey. The survey in mimeographed form will be given out to the three upper classes in the Institute. With these questionnaires will be given self-addressed envelopes, to be put in Institute mail boxes, in order that The Tech Engineering News may get the replies conveniently and expeditiously. It is the aim of The Tech Engineering News to get as close to the mean of the students at Tech as is possible and to this end the replies from the survey will be compiled. The results will be announced in the January issue of The Tech Engineering News.

We ask your coöperation in running this poll of student life in order to provide a better solution to numerous administration problems in regard to student life at M. I. T.

The content of the questionnaire is as follows:

1. Class.....; Rating.....
2. Where do you live? In dormitory.....; In a fraternity.....; As a commuter.....; As a roomer or boarder.....
3. Approximately how do you spend the *average* week? In considering average, take a mean of the first fifteen weeks of school.

Activity	*Average Time Spent Per Week (Hours)*
a. Considering cuts, Classes (including Labs and Lectures)	.....
b. Assignments	.....
c. Hours more or less than the prescribed amount on assignments	.....
d. Reading for further education in addition to the assignments including newspapers	.....

(*Continued on page 180*)

Plowing in a 1600 mile telephone furrow *for defense*

To assure coast-to-coast telephone facilities adequate to meet future defense needs of the nation, the Bell System is constructing a 1600 mile, $20,000,000 cable line between Omaha and Sacramento.

Several newly developed "plow trains," working from opposite ends of the line, are burying the cable for maximum protection. They dig deep furrows, lay two cables in them and cover them with earth — all in one continuous operation. Their meeting will mark completion of the first *all cable* line across the continent. Carrier systems will be operated in the cables —one direction of transmission in each.

This vast project is just one of thousands in which the Bell System is now engaged to provide additional communication facilities so vital to Army, Navy and defense industries.

BELL SYSTEM

BRIEFING THE NEWS

SUGAR-COATED STEEL

Sugar-coated steel is a new product of the steel industry, produced not to satisfy sweet-toothed consumers but to improve the surface of the steel.

The sugar coating is applied by a recently patented process in which absolutely dry, pure corn sugar is blown on the inner surface of the ingot molds.

When molten steel is poured into the molds, the coating tends to prevent splashed metal from solidifying on the walls of the mold. Defects are likely to develop in the steel if the surface of the mold is not kept smooth. Sugar is the newest mold coating to be tried by steel companies, but pitch, tar and other materials have been used for years.

When sugar is used and temperature of the steel is right, the ingot is given an attractive, shiny caramel coating. The coating disappears during later manufacturing processes, and cannot be detected by the ultimate consumer of the steel.

— *Steel Facts.*

MAGIC MINERAL

T.N.T. and perfume; Nylon stockings and spectacle rims; indigo and other popular dyes; lysol and oil of wintergreen; beads and buttons; embalming fluid and phonograph records — these and many other products are derived from coal. All of them are obtained as by-products from the manufacture of coke. The by-product oven differs from the older beehive oven in that it conserves gases and vapors liberated when coal is coked. This provides raw materials for a variety of products.

Bethlehem Steel

The amount of tar obtained from each ton of coal coked averages about eight gallons. The tar is valuable as a fuel, as road tar and certain grades of it are distilled for the recovery of such products as creosote oil, pitch, naphthalene and carbolic acid (phenol).

Creosote oil is used to preserve railroad ties and wood products. Pitch is employed for roofing work, for waterproofing concrete and masonry, and in manufacturing battery boxes, electrodes and foundry cores. Phenolic resins, important sources of plastics, are used in such products as telephone receivers, radio panels, bottle tops and automobile trim. Phenol derivatives are found in many disinfectants.

The principal products derived from light oils (about three gallons per ton of coal coked) are benzol, toluol, xylol, naphtha and naphthalene. About 80 per cent of the benzol produced is blended with gasoline to produce a superior motor fuel. The remainder finds wide use in chemical industries.

Toluol's most important use is in the manufacture of T.N.T. (tri-nitro-toluene). While some toluol is produced from petroleum, its main source is coal distillation. Another service made possible by light oil derivatives is the manufacture of vulcanization accelerators and anti-oxidants which increase the life of auto tires. Ammonia, the third major product recovered from coke oven gas, is used for ammonium sulphate fertilizer, containing nitrogen.

Many of our most needed medicines are coal derivatives, among them novocaine, and the new products, sulfanilamide, sulfapyridine and sulfathizaole, which effected cures of pneumonia, meningitis, and other dread infections.

Truly coal is a magic mineral. Furnishing indispensable fuel for industrial use, it provides also a wide array of products essential for national defense and normal peace-time pursuits.

—*United States Steel News, October, 1941.*

NEW SHEET STEEL THICKNESS GAGE

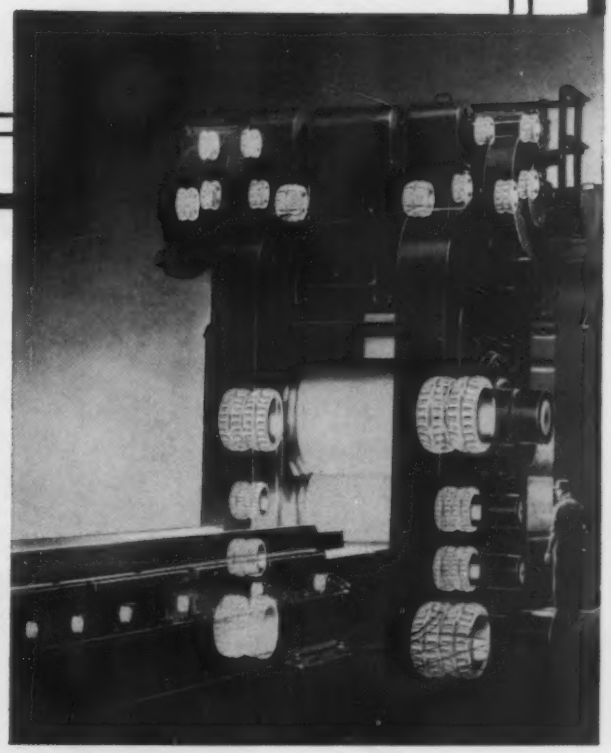
A new magnetic gage which for the first time measures the thickness of sheet steel when only one side is accessible has been invented by General Electric engineers. The gage is accurate to one-thousandth of an inch.

It consists of a seven-pound portable indicating unit, which is connected to an electric outlet, and a small cylindrical head containing an alnico magnet. When the gage head is placed against the material to be measured, the permanent magnetic field of the head saturates the material. How much magnetic flux passes through the gage head magnetic circuit depends on the thickness of the material. This thickness is indicated by the instrument reading which is a measure of the increased reluctance of the magnetic circuit.

Thickness of any magnetic sheet or plate material may be measured by the gage as long as the material is not backed by other magnetic material. The gage is especially valuable for checking the center and other points on wide sheets of steel where the use of calipers is inconvenient or impossible.

Gages can be made to measure thicknesses up to 250 mils (one-quarter inch) with the same relative accuracy and even thicker if portability is sacrificed.

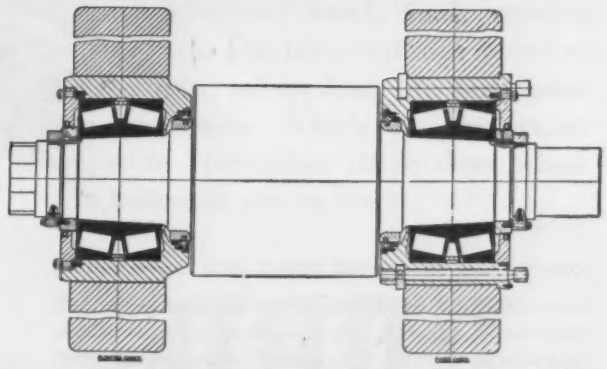
What Bearings would you specify for a Steel Rolling Mill?



Let's assume that you were asked to design a 4-high continuous strip steel rolling mill to operate at a rolling speed of 2,000 feet per minute. What bearings would you select for the necks of the back-up and work rolls?

If you knew your bearings you would specify Timken Roll Neck Bearings. Then you would be sure of smooth mill performance at all speeds; steel rolled true to gauge at all times; simplified lubrication; long bearing life (Timken Roll Neck Bearings hold all records for tonnage rolled); easy roll changing (no delicate parts to handle); fewer involuntary production interruptions.

This is but one of thousands of bearing applications in industrial machinery where Timken Bearings have proved their supremacy. When you have gained a thorough knowledge of Timken Bearings you will be in position to solve any bearing problem you may ever encounter. Write for a copy of the Timken Reference Manual—a valuable text book.



THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

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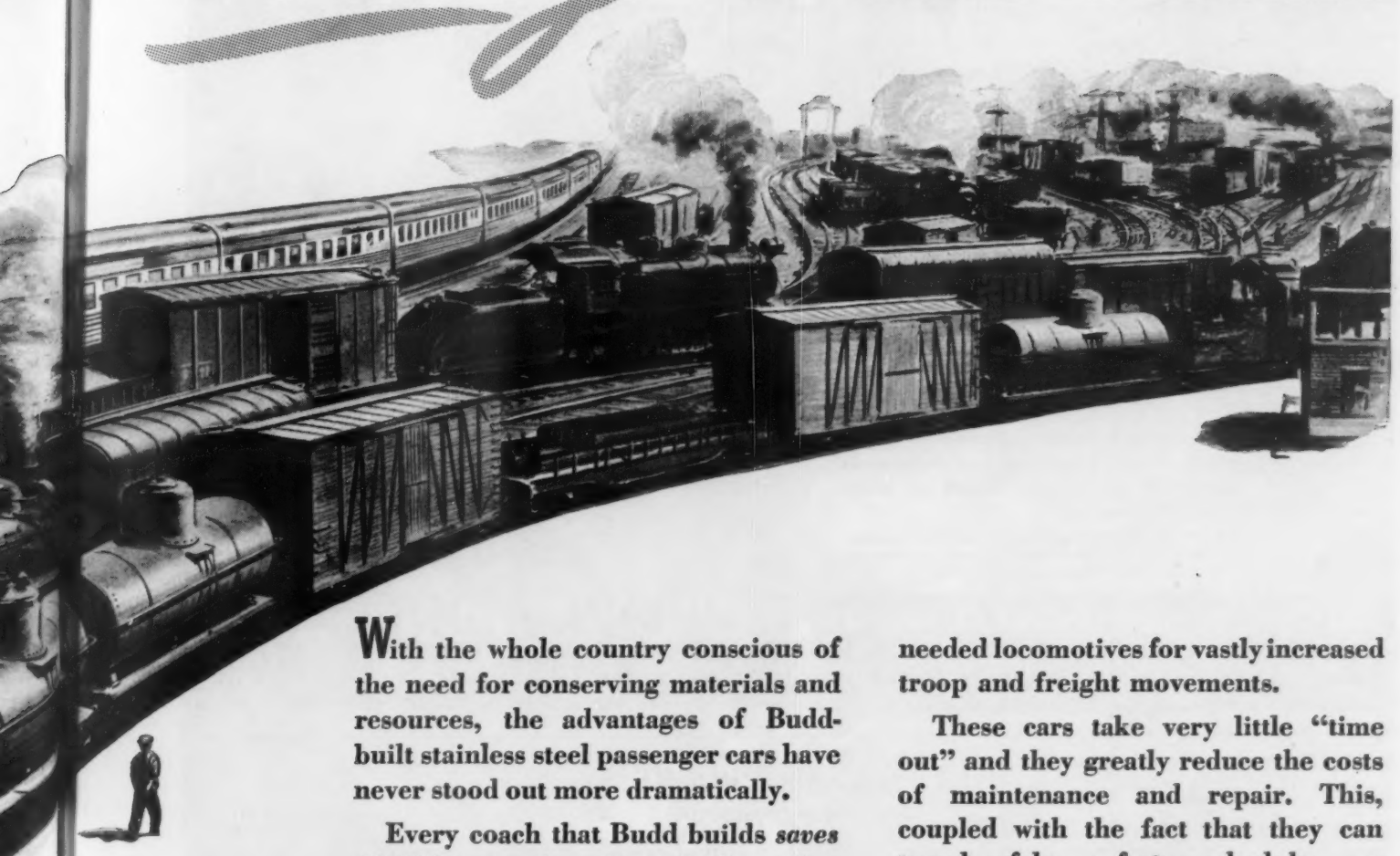
Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

Why Stainless Steel Trains

BUDD

CARS SAVE STEEL FOR DEFENSE

belong in This Picture



With the whole country conscious of the need for conserving materials and resources, the advantages of Budd-built stainless steel passenger cars have never stood out more dramatically.

Every coach that Budd builds *saves 40,000 pounds of steel for other Defense purposes.* In addition, Budd research, constantly striving for improvement, has developed the use of a new and superior stainless steel. Utilizing manganese, it saves about half the nickel formerly used.

By through-and-through stainless steel construction, and fabrication by the exclusive SHOTWELD★ system, Budd cars are made light weight without sacrifice of either strength or safety. Because of this saving in weight, they cost less to haul. They save fuel. And they save one-third the motive power, releasing many badly needed locomotives for vastly increased troop and freight movements.

These cars take very little "time out" and they greatly reduce the costs of maintenance and repair. This, coupled with the fact that they can travel safely on faster schedules, enables a Budd stainless steel car to do the work of three ordinary cars.

Budd stainless steel cars are the only railroad passenger cars that combine such savings of steel, fuel, motive power, time and labor without sacrifice of strength, safety, long life and maintenance costs. That's an important point to remember these days when the railroads are so busy.

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BUDD helps arm every branch of the service

Bodies for tough Army cars and trucks, bombs and shells, stainless steel parts for fighting planes and Navy ships today stream off Budd's production lines. Arming America's defenders is Budd's most urgent business today.

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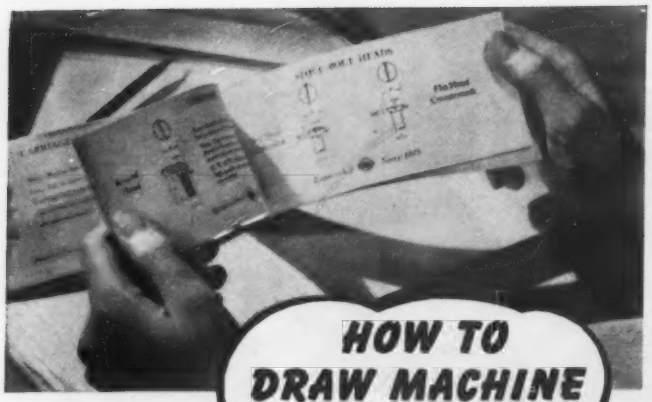

HOW TO DRAW MACHINE FASTENERS

• The "RB&W Handbook of Common Machine Fasteners"—sent absolutely free upon request — shows the most widely accepted methods of representing more than thirty different types of standard bolts, nuts, rivets, etc., on assembly and detail drawings. This 16-page booklet will fit inside your drawing instrument case for handy reference.

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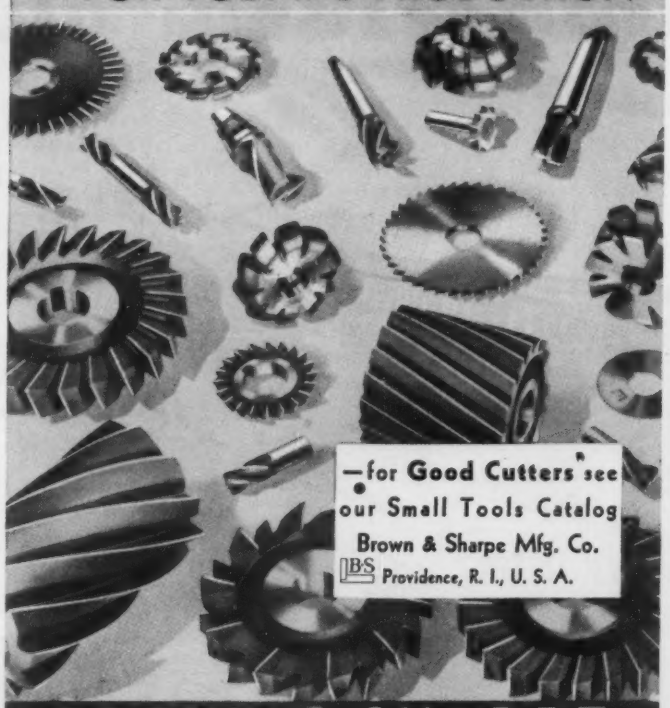

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BROWN & SHARPE CUTTERS

GEARS MEAN PROGRESS

(*Continued from page 166*)

of a grinding wheel for either generating or finishing gear teeth is shown.

The hobbing method is probably by far the most popular of modern methods for producing spur and spiral gears as well as splined shafts and other forms. This method has many advantages: first, it continuously rotates the cutter and also the blank, thus distributing the heat evenly around the blank. It also promotes rapid production, and has long sustained accuracy, since the various parts of the hobbing machine, as it is called, are in continuous rotation while the gear is being produced. The hob, which resembles a rack, is set at an angle to the work.

Among the various types of gears, in addition to the common spur gears, are standard straight-toothed bevel gears, which allow the shaves to be at an angle, and the skew bevel gear, a forerunner of the popular spiral bevel gear developed by the Gleason Corporation. It is shown in Figure 4. It has many advantages over the straight-toothed bevel, the chief one being that teeth are more continuously engaged and consequently give a more quiet and even action. Prior to the development of the hypoid gear this type was almost universally used in automobile and truck rear axles.

The oldest form of worm gearing consisted simply of a worm meshing a straight-tooth spur gear, the worm being inclined until its helix angle is parallel with the line of the spur gear teeth. By inclining the teeth on the spur, the axis of the worm may be maintained parallel to the side of the gear and at right angles to the axis of the gear. The efficiency of a worm gear can be further increased by making the teeth of the spur concave so as to fit partly around the worm and thus gain a larger area of contact.

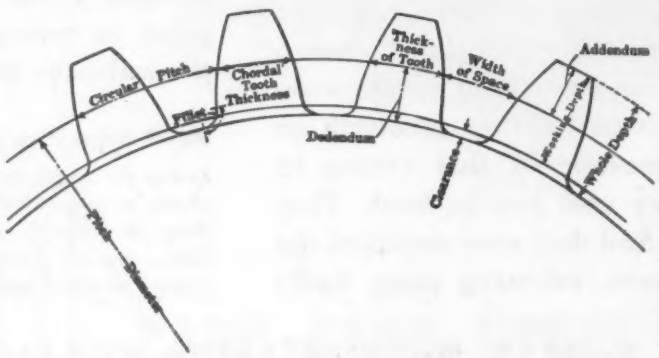
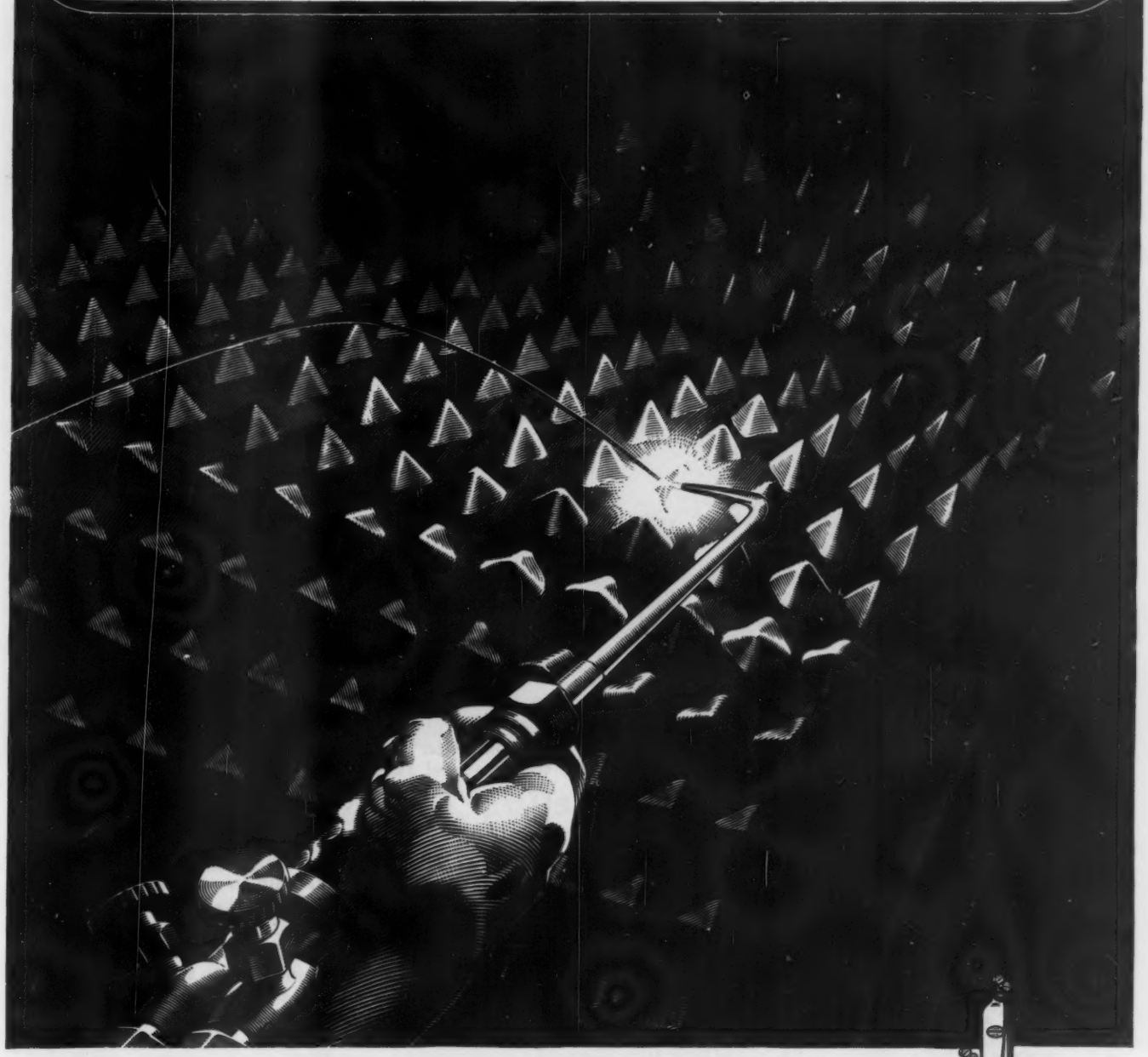


Figure 6
Nomenclature of the various parts of involute gear teeth

Figure 5 shows the Hinley, Lanchester, or hourglass type of worm and worm gear. This type requires highly specialized methods of manufacture for best results, but when the teeth of both the worm and gear are accurately generated, a great increase in bearing area can be expected. Some makers of this general type of gearing claim as much as

(*Continued on page 176*)

"FACE-SAVING" 20th CENTURY STYLE



WORN teeth no longer render crushing equipment useless, nor do they mean long, costly delays. Today there is a simpler, faster, less expensive way — hard facing with the Airco Oxyacetylene Flame. Reports indicate that teeth built up by this proved Airco process last longer, yet cost only 25% of a new segment. Cost of replacing the entire crusher is, of course, far greater.

Airco Hard-Facing is a versatile process. Wearing parts of varying shape and size can be rebuilt economically, speedily. Standard oxyacetylene welding apparatus is employed.

Not only for maintenance of equipment, but on thousands of production lines, the Airco Oxyacetylene Flame is on the firing line speeding countless defense products to completion. It has been drafted to cut steel to any desired shape, to flame harden metal parts for longer life, to weld two or more metal parts into a strong, lasting unit, to machine metals with unrivaled speed, to clean and dehydrate metal surfaces for lasting paint jobs.

A pictorial review "Airco in the News" shows in an interesting manner these many uses of the flame. Write for copy.

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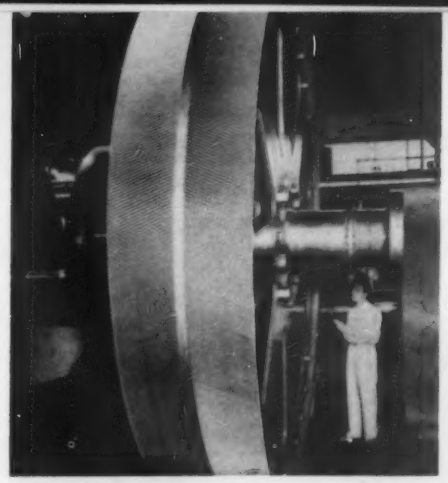
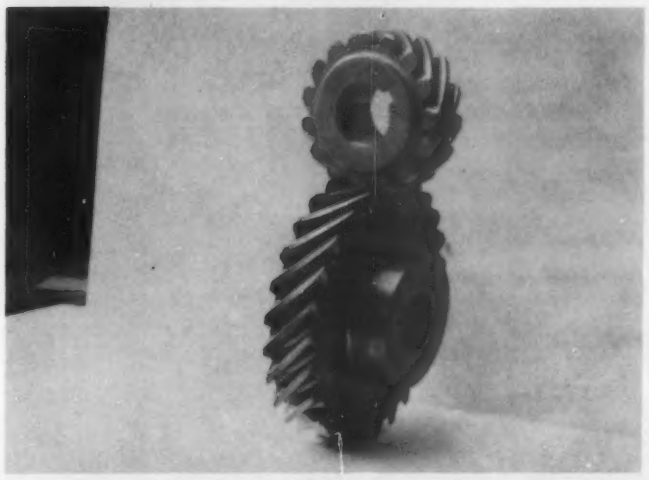
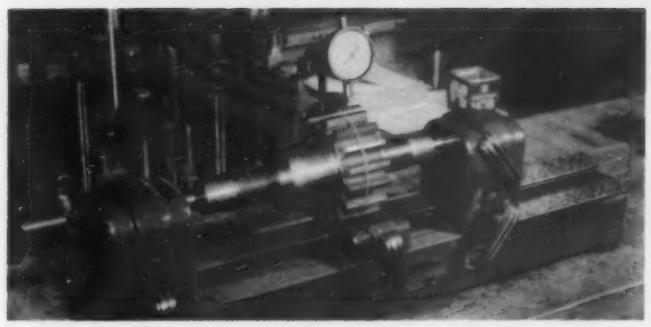






Figures 7, 8 and 9

GEARS MEAN PROGRESS

(*Continued from page 174*)

four times the available unit load over the conventional type of straight worm and worm gear.

It is evident that one of the most characteristic things about any gear is the shape or form of its teeth. One of the first scientifically designed tooth shapes was the cycloidal form. It is produced by rolling a circle on the theoretical pitch line of the gear, the circle being rolled above the pitch line for the upper part of the tooth and below the pitch line for the lower section of the tooth. This type of gear was at one time practically standard, but is now almost obsolete.

The modern gear tooth employs an involute curve, which insures correct action between mating gears. It also insures smooth rolling action, even when gears are not on the exact theoretical centers, as the involute curve will take care of considerable divergence from the figured gear centers. Furthermore, the involute curve can be generated from a straight line element, which means that the same tool can be used to generate gears of different sizes and numbers of teeth. For example, a hob of any given pitch will generate gears comparable to the whole range of gears covered by 15 Brown and Sharpe formed cutters, and in addition will do the generating more accurately. There is a lower limit to the number of teeth, since below 31 teeth on a 14½ degree pressure angle, interference begins to appear; but from 31 teeth on up the hob will generate accurately any number of teeth required in the work. In addition this same hob can be used to generate spiral gears, a point which will be taken up later in more detail.

Figure 6 shows involute gear teeth and the usual nomenclature of the various parts. The diametral pitch is the number of teeth to each inch of pitch diameter; the circular pitch is the distance from the center of one tooth to the center of the next measured along the pitch line; the chordal thickness or the corrected tooth thickness is the thickness at pitch line measured in a straight line; the addendum is the portion of a tooth above pitch line, while the dedendum is the portion below; and the clearance is the space allotted between the top of one tooth and the bottom of the groove. All dimensions have various pitches, but involute curves are standardized and may be found in most handbooks.

The pressure angle may be described as the angle which the side of a rack tooth describes as measured from the vertical when the rack is lying in a horizontal position. The pressure angle is usually 14½ degrees; but when the pinion is less than 31 teeth, a higher pressure angle is often used to avoid interference and undercutting, 20 degrees being very popular and other angles such as 22½ degrees, 25 degrees, or even greater being employed. To strengthen a small pinion it is often advisable to raise the pitch line and the root diameter. This is often termed the long and short addendum system, as it results in the pinion having a long addendum sometimes almost coming to a point, but with a strong root portion.

A very large spiral gear is shown in Figure 7. Such gears are used in pairs, and are used with the respective axes either parallel to each other as in the case of a transmission, or at right angles. When run together with parallel axes, a pair of gears must, of course, be of opposite hands, a right-handed gear, for example, mating with a left-handed gear. This point is often overlooked by designers. One of the chief advantages of spiral gears is their quietness, this quietness increasing as the helix angle increases up to a certain point. Some gears have a helix angle as high as 60 degrees, although 45 degrees or less is more usual.

Probably the most outstanding spiral gears are the enormous steel gears running up to 20 feet in diameter and about 36 inches face width which are used in the drive between the steam turbine and propeller shaft of ocean liners or battleships. These gears are of relatively fine pitch and have a helix angle of about 30 degrees. They are the last word in speed, power, finish and general accuracy. They sometimes have to run at the terrific pitch-line velocity of 17,000 feet per minute, whereas most commercial gears do not exceed a speed of about 1000 feet per minute.

Spiral gears are quite often used to transmit motion between shafts at right angles to each other. This construction, however, is not to be recommended except where the speed is low and the power to be transmitted very small. This construction will work, for example, where some slide is to be operated by hand at intervals, or where only a small amount of power is to be transmitted. These gears have only a point contact, or the contact obtainable between two spheres, and are further subject to a high degree of rubbing action, so that no matter how well the gears may be lubricated excessive wear may be expected with (*Continued on page 178*)

TWO FEDERAL AGENTS
ENTER FIRE PROBE—
SABOTAGE "POSSIBLE"
Federal agents arrived today to take part in the investigation of the disastrous fire that stopped production on important defense

Learning The Cause Won't Fill The Orders

The shafts have stopped turning. Hands that can set a tool-rest to a hair are wrapped around pool cues down at Joe's place. Mirror finishes on Assembly's floor are dimming over with the first hints of rust.

Learning the cause of your fire won't help. What you wanted was the chance to produce – without Fire's interruption. Perhaps you counted on a "fire-proof" building. Or on employees trained to be ever-watchful. *You can't* – as the record of thousands of fires will show. The record proves that there's only one way to stop fire at its source. That way is automatic sprinkler fire protection.

Fortunately, there isn't the slightest need to compromise with quality when you install it. For the world's best-known fire protection system – Grinnell – can be bought as an actual cash-dividend-paying investment. The chart below proves it.

Built lock, stock and barrel by the world's leader in fire protection; prefabricated to a Grinnell-engineered layout, then installed with minimum disruption; proved dependable by eight thousand fires killed in the past ten years alone – a Grinnell System is the best guardian of spinning shafts your plant can have. Owners of fifty billion dollars' worth of the world's property have chosen it. Take *your* first step today. Write Grinnell Company, Inc., Executive Offices, Providence, R. I. Branch offices in principal cities.

QUESTIONS and ANSWERS
about Automatic Sprinkler Fire Protection

Q. Who says I'm not protected? I have complete insurance coverage!

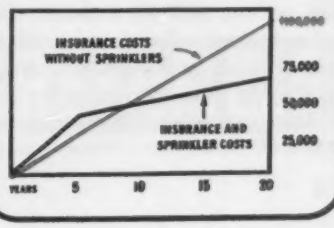
A. 43% of all burned businesses are never resumed, regardless of insurance.

Q. My building is metal; its contents are non-combustible. Why should I have sprinklers?

A. A metal mill burned to ruins in an afternoon. Oil vapor had condensed on inside walls.

Q. What do you mean – a Grinnell System pays for itself?

A. The chart shows a typical case. Insurance without Grinnell System, $5,000 yearly. With Grinnell, premium reduction paid for the system in 8-1/3 years. After that, $3,000 a year clear saving!



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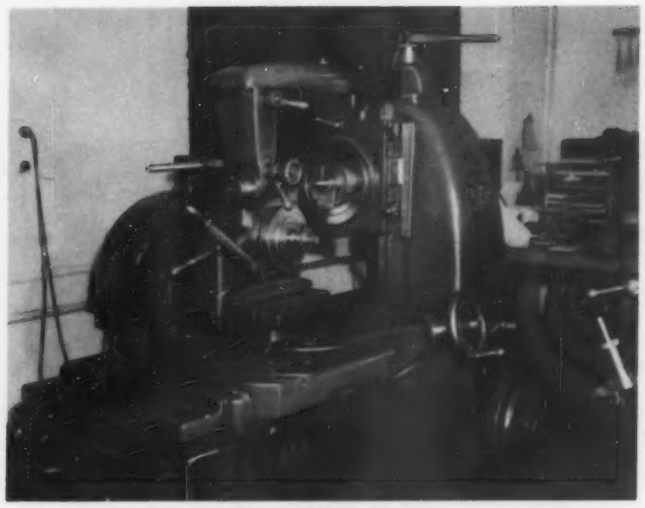

Figure 10. Speeder for testing gears

GEARS MEAN PROGRESS

(*Continued from page 176*)

consequent early failure if there is much power transmitted.

A type of gearing designed to avoid this trouble is shown in Figure 8 installed in a Barber-Coleman Hobbing Machine. It employs two pairs of gears, each pair composed of one spiral gear of conventional type and one spiral bronze gear which has curved teeth like a worm gear. This gives a line contact instead of a point contact and greatly prolongs the life of the gear.

The quality of the blank is of great importance in the manufacture of the precision gears. While it is possible to cut a good gear out of a poor blank, it is almost impossible to check the gear afterward. Whenever a precision gear is to be made it is necessary to begin by grinding the hole, grinding the sides flat and parallel, and grinding the outside diameter close to the correct figures. This gives the hobbing machine operator a chance to true up the blank accurately before he hobs the gear, and gives the inspector a chance to check the gear later with some assurance that his check is correct.

Gears for high speed, precision machines must be inspected carefully with elaborate devices. Figure 9 shows a standard bench center with a gear being checked for pitch line run-out, a very important factor as it determines the true running of the gear in service and hence its quietness. A similar arrangement checks for side run-out or wobble. A simple yet accurate check for eccentricity on pitch line, amount of backlash, smoothness of rolling, and amount of kick-out can be made by turning the gear with a master gear employing a pair of carefully centered arbors. Special calipers are employed to check the dimensions of each tooth. Although turning with a master gear gives an indication of the correctness of tooth spacing, any irregularities resulting in binding, there are elaborate instruments employing Zeiss collimeters and theodolites which give a direct check.

Special types of gears require special test instruments. For example, the helix angle of spiral gears must be measured, for if this is not correct, the gears will never work smoothly and the bearing will probably come on the end of a tooth with a resulting fracture. The quietness of operation of a gear and the position of the bearing or zone of contact can only be determined by running the gears at very high speeds. A machine for this purpose, known as a speeder, is shown in Figure 10.

(*Continued on page 186*)

WHAT'S AHEAD?

(*Continued from page 161*)

engineer and the mechanic the state of his product; and in hosts of industrial operations, electrical circuits control the processing. This field of measurement and control is large and rapidly growing with much new and fascinating work to be done, often in industries that in no way concern themselves with electrical products — a fact too often ignored by electrical-engineering students in considering industrial careers. Graduates in their twenties — here, as in all other growing parts of the field — are really "going places and doing things" that evoke recognition.

Utilization of electrical energy includes many, many other problems for the engineer. Electrical geophysical prospecting, high-voltage X-ray generators, the electron microscope, machine tool drives and controls, airplane electrical equipment (an astounding amount goes into a modern transport plane), electrical illumination in its many forms, whose science and aesthetics are both striding ahead, the multitude of appliances and tools for the home as well as for industry, are typical of fields in which recent and current developments are particularly active. Some of these will continue active for a long time; other new utilization fields will open. Each new development of this sort requires a surprisingly large amount of engineering, particularly where large quantities are involved and unit costs become exceedingly important.

In all three phases of electrical engineering, is a trend worthy of note, the continuous advance from empiricism and "gadgeteering" to rigorous analysis and rational design. At the turn of the century, mathematics which is currently accepted and used as a matter of course by every sophomore in engineering was conspicuous by its absence from electrical-engineering literature. Any discreet young engineer usually kept his mathematical attainments well camouflaged until he was sure he was among friends. Now editors accept as commonplace, papers freely using mathematics of graduate level, for these merely reflect the current methods of thought of practicing engineers. No sign of change in this trend is visible, indeed it appears to be intensifying, for the engineer who brings his mathematics to bear really effectively on his problems is unquestionably making the significant technical advances today.

One other trend deserves notice. The term "streamlining" has become disreputably threadbare if not positively repulsive from overuse and abuse. Yet the idea that sincere and functionally sound aesthetic design in a power station turbine room or in an electrically controlled and driven machine tool is not fundamentally incompatible with its technical efficiency is beginning to appeal to even the hard-boiled engineer. Any such major reorientation necessarily produces some abortive designs but the day of the uncouth machine is waning, and the engineer in looking ahead had better reconcile himself to artistic restraints or better still sympathetically incorporate them into his own thinking.

Little mention has been made of defense, to ignore which is to shut one's eyes to present actualities. Suffice it to say that absence of such reference is properly interpreted as the emphasis of understatement. Were the vast amount of electrical defense development less significant, the public would be much more aware of it. The number of urgent requests of the Army, the Navy, and defense industries for adequately trained electrical and other engineers, amounting to several times the number of men available, is most concrete evidence of the feverish activity in new things electrical, the nature

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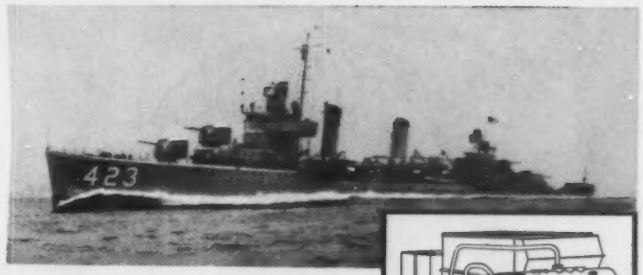

POWER FOR DEFENSE

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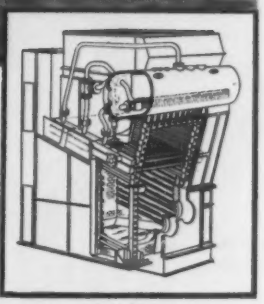

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of which we can glean but vaguely from the news items about degaussing of ships, location of airplanes, and such. Electrical students are being signed up a year or more before graduation.

What effect is this defense effort likely to have on the electrical field ten years hence? One bright spot in the otherwise dark and forbidding picture of war is the fairly high peace-time salvage value that may be expected from at least some defense developments. Paradoxically, navigation by air and sea will unquestionably be safer because of the hazards of war. One may reasonably expect that communications, so vital to all military operations, may receive some long-term gains; likewise, many utilization functions of electricity in war have their counterpart in peace. Electric power is fundamental to our industrial civilization, independent of peace and war. In looking ahead to peace, the necessity of reabsorbing many people in new jobs calls for new products, new and better facilities for manufacture, transport, and communications, in which electricity is bound to play a major part.

How can the present student best meet his current obligations and still be prepared for the future? Fortunately both require one and the same thing, namely, development of the best professional proficiency of which he is capable. As all Technology students are aware, the engineer is considered so valuable serving in his professional capacity that selective-service boards have been advised by Deputy Director General Hershey to give the most serious consideration to the deferment of every competent student in the major branches of engineering, even though it may be three years or more before his formal training as an undergraduate is to be completed. Graduate training comes in the same category. (*Continued on page 186*)

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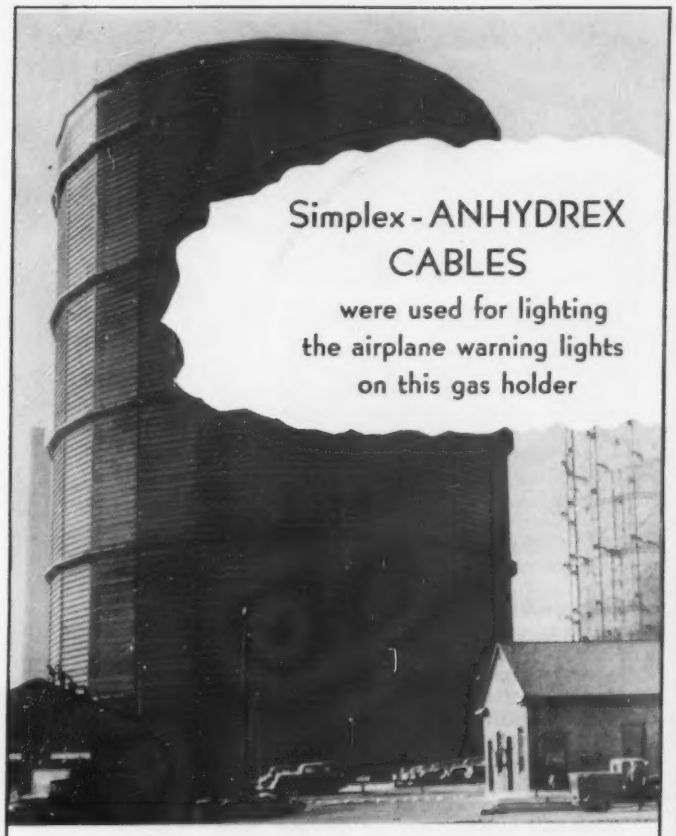

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FRANKLY SPEAKING

(*Continued from page 168*)

Activity	*Average Time Spent Per Week (Hours)*
e. Amount of time spent in the Institute Library or its branches	.....
f. Reading for enjoyment	.....
g. Listening to music (classical and swing)	.....
h. Sleep	.....
i. Eating (except for banquets):	
Breakfast	.....
Lunch	.....
Dinner	.....
j. Do you eat alone or with somebody?	.....
k. Social life (dates, dances, etc.)	.....
Of this total time, approximately how much of it is spent at the various girls' schools in or near Boston?	.....
l. Institute extra-curricula activities	.....
m. Other extra-curricula activities outside the Institute	.....
n. Work for pay except for coöperative course	.....
o. Outside work without pay	.....
p. Bull Sessions	.....
On what subjects	.....
q. Time spent in travel to M. I. T.	
In trains.....; autos .....; trolleys.....; walking.....	
r. Any other way in which an appreciable amount of time is spent in an average week not covered by the above questions?	.....

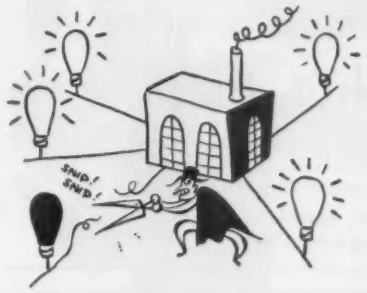
4. In which M.I.T. extra-curricula activities are you at present engaged?
5. With the experience of at least one year behind you, if you were planning to enter M. I. T. as a freshman, how many hours per week would you plan to devote to Institute extra-curricula activities?
6. What do you feel is the ideal time for a man in your class and your course to spend in extra-curricula activities? (Assume ability in school work equal to your own.)
7. Do you belong to the professional society connected with your chosen course in the Institute?
   Yes.....; No..... If not, why not?
8. What is your course?
9. Do you feel that, in this course, M. I. T. offers the best engineering, science, or architecture curriculum in the country (*i.e.*, assuming a four-year course as preparation for work in the field suggested by your course, and also going on the premise in answering this that you have merely your own personal opinion to guide you in your decision)?
10. Do you attend church?
    Regularly.....
    Occasionally.....
    Once in a long while.....
11. If you are not in Institute athletics, do you take any regular exercise? If so, approximately what does it consist of?
12. Do you avail yourself of:
    a. Swimming pool.....
    b. Squash courts.....
    c. Tennis courts.....
    d. Sailing facilities.....
13. How much time do you spend in consultation or informal visits with members of the Institute faculty and administration?
14. What was the predominant factor which led you to select the course which you are now taking? (It is naturally realized that this question is very difficult to answer but we would appreciate some idea of the factor that finally led you to make the decision that you have made.)

When power must not fail!

How a Westinghouse Distribution System Foils Lightning, Accidents, and Saboteurs

BEHIND America's urgent defense production, stands electric power. It runs the machines that turn out the weapons for the defense of America. It must not fail, must not even falter.

In the first World War, this vital power could be cut off, and cut off easily . . . by saboteurs, by accidents, or by lightning.



► For, in those days, the *only* means of distributing electricity was through *radial* systems, in which the power lines radiated like the spokes of a wheel with the power station as the hub. So, if *any part* of a power line were damaged, no electricity could be delivered to users *all along the line*.

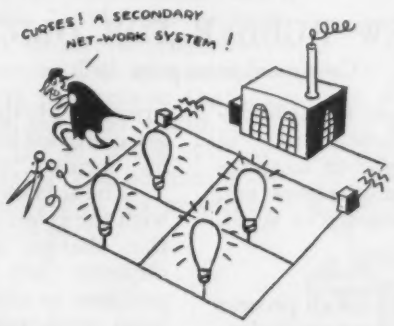
No way was known to reduce the vulnerability of power distribution until the early '20's, when engineers of a large power company conceived the idea of the *secondary network system*.

► The idea was to connect low voltage secondary lines in a *network*, with the main power (primary) lines joined to the network at several places. Thus, with power being sent along several different routes, a line could be damaged and electricity would continue to flow to its users along the other routes.

It was a great idea . . . if it could be made to work on large and complicated city systems. That was the problem, a problem which the power company brought to Westinghouse engineers.

► The secondary network system wouldn't work at all until some pump-proof method was found to keep power from flowing backwards into a damaged section of the line. Westinghouse engineer John S. Parsons (a member of Georgia Tech's class of '21, a graduate of the Westinghouse Training Course, and the holder of 30 of the 150 patents on secondary networks) found the way . . . a pump-proof relay which, when power is flowing in the wrong direction, closes its contacts and causes a network protector (automatic air circuit breaker) to trip and cut the feeder off the line.

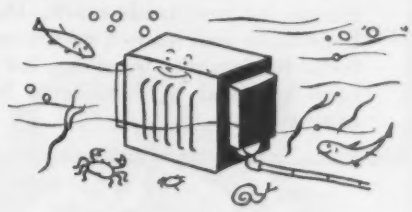
Then, there was the question of where to put the transformers, relays, and protectors that secondary networks needed. The amount of space this equipment would take up would be tremendously expensive in crowded cities.



► The obvious way to overcome this obstacle was to put this secondary network equipment underground. But transformers, relays, and protectors wouldn't perform properly in damp underground atmosphere. Westinghouse engineers went to work and developed a transformer-relay-protector unit that could fight off dampness and perform as well underground as above ground! Now, there are network units that do their job even though submerged under salt water, twice a day!

To make doubly sure that they had the space problem licked, Westinghouse engineers cut down the size and stepped up the power capacity of these network units. They made it possible for a unit that was one-third smaller to do the same electrical jobs!

► Secondary networks raised all sorts of new problems. And Westinghouse engineers had to find a lot of new answers before they were able to bring secondary networks from an idea to a working distribution system.



Today, Westinghouse engineers have brought secondary network systems to 164 cities. They've adapted these systems to the specialized needs of defense plants, army camps, airports, and power houses. Their work has contributed tremendously to today's ability to distribute unfailing electric power . . . despite lightning, accidents, and sabotage.

★ ★ ★

► This story illustrates how Westinghouse engineers work. More than that, it shows how the Westinghouse Company works. For there are 1,500 engineers in Westinghouse . . . in service, in management, in design, in sales, in every single branch of the business. These engineers give the company its point of view.

Westinghouse takes pride in the engineering behind its products. Its engineers are always analyzing its products, working over them, making them better. It has the engineer's impatience with the old and his eagerness to create the new.

► Engineers founded and built Westinghouse. Engineers will carry it on.

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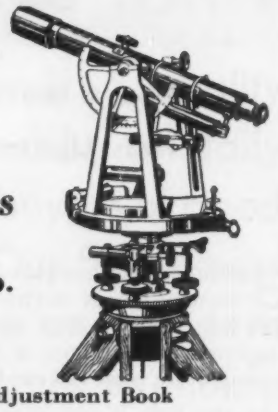

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NEW RUBBER FOR OLD

(*Continued from page 167*)

discarded automobile tire; other forms are the automobile tube, boots and shoes, belting, hose, and — in smaller volume — a host of rubber scraps from factories and the consuming field. The collection, classification, and sorting of rubber scrap forms an industry in itself.

Whole-Tire Reclaiming

The reclamation of whole tires by the alkali process produces the greater part of the reclaim tonnage today. The scrap is most plentiful and will always be available, two most important considerations. It is natural, therefore, to find this process developed into a well-standardized, mass-production operation.

1. Selection of Scrap.

Whole-tire reclaim was produced originally from all road-worn passenger tires. This product possessed certain properties, such as specific gravity, ash, tensile strength and elongation when cured in test formulae, softness, smoothness, etc. Customers had adjusted their practices to these properties. When truck tires came on the scrap market, it was found that they altered some of these properties, chiefly in respect to toughness and smoothness. The new product did not work into customers' formulae with the same results in processing or in products. But not to use truck tires would result in the loss of a source of cheaper scrap, and eventually would cause a rise in reclaim costs to the point of curtailed demand.

Therefore the reclaimer has resorted to the addition of other scraps selected to affect the property changes wrought by the use of truck tires. He is constantly searching for low cost, readily available scraps to adjust his "formula" to give a uniform product from his plant.

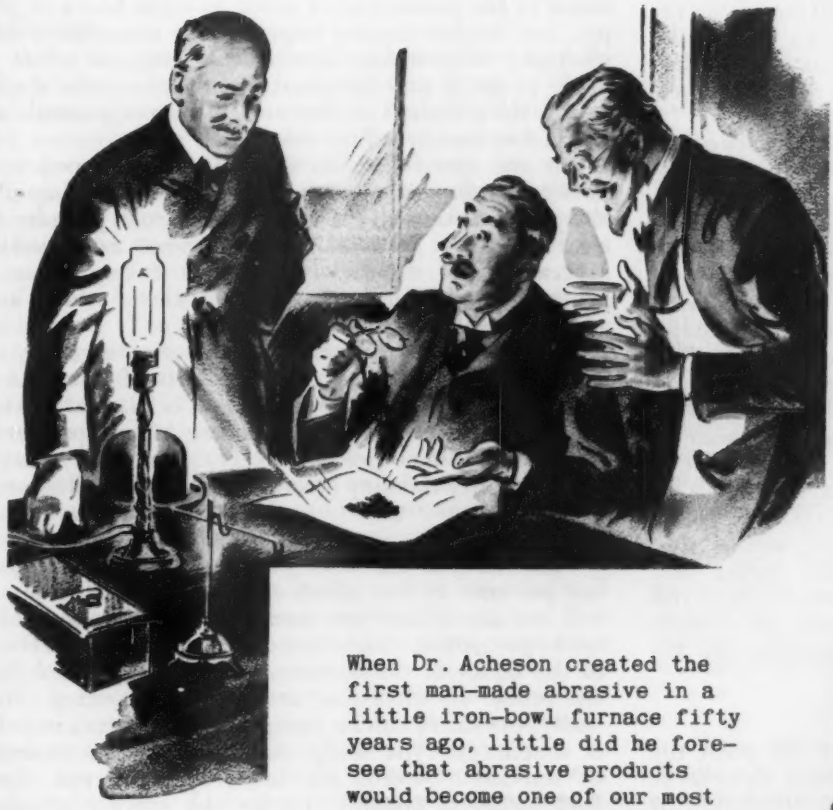
The scrap available on the market changes in volume with the growth of the use of rubber goods. Its composition changes as the rubber technologists constantly improve their product. This offers the reclaimer a problem to which he never finds the final answer. He must work continually on the problem of a product low in cost and constant in quality, manufactured from raw materials whose cost, availability and properties change continually. Thus today's formula may be worthless tomorrow.

The formula control lies in initially small batches of test material run in semi-plant units, simulating plant conditions. If the results are desirable, a full scale batch or two may follow, until the technical men are satisfied with the product. Then follows the real test, that by the consumer; for on the results in his use depends the future of the reclaim in question. The reclaimer must possess, or develop in his use, the right tackiness (or dryness), the right ease and completeness of dispersion in his formula and yield at least as good a final product as was obtained before.

Most commercial reclaimers today produce a varied assortment of standardized whole-tire reclaims, intended to provide combinations of properties to satisfy the many different needs of the customer. While the process is controlled to these standards, it is considered good practice to plant test all but quite minor formula changes.

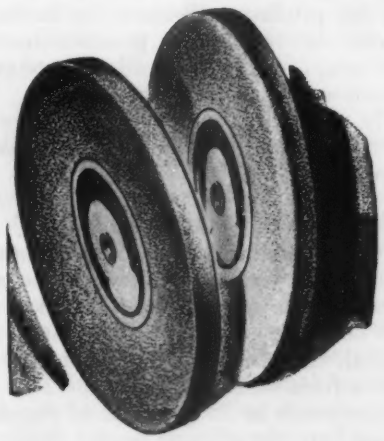
(*Continued on page 184*)

Was $880.00 a pound...NOW 16¢!



"You really made these crystals in an electric furnace?" the gem expert asked. "They look as if they'd been in the earth a million years!" "Certainly I made them", said Dr. Acheson. "And all I ask is that you crush them and try them instead of diamond dust for gem polishing." The expert did...and placed an order at $880 a pound! Today this same Carborundum Brand Silicon Carbide serves all industry, sells in grain form for as little as 16¢ a pound.

When Dr. Acheson created the first man-made abrasive in a little iron-bowl furnace fifty years ago, little did he foresee that abrasive products would become one of our most important production tools... that one day they would be used in the grinding, finishing, shaping and polishing of practically all the products of all industry.



Today, our outstanding research, manufacturing and engineering facilities are ready to serve you no matter what industry you may decide to go into. The Carborundum Company, Niagara Falls, New York.

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ABRASIVE PRODUCTS
50 YEARS OF SERVICE TO ALL INDUSTRY

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NEW RUBBER FOR OLD

(*Continued from page 182*)

2. Preparation of Scrap.

Tires are usually on the market as debeaded tires. Other scraps in use are often in sizeable pieces. The processing starts, therefore, with the sizing of the weighed-out formula. The scrap is first put through a chopper, usually of the rotary or swinging knife type, to reduce it to pieces not over one and one-half inches by six or seven inches. Large tires are first split down the middle of the tread, and then cut into three to six sections for chopping. The average passenger tire is fed whole into the chopper.

The chopper output is then fed to a two-roll "cracker" which has heavy, sharp-edged flutings. The rolls pull the pieces through the "bite," crushing or macerating them, at the same time shearing off small pieces. The product is usually screened to a predetermined limit of particle size; the oversize returning to the crackers continually. The fines through the screen are crushed and also cut particles ranging from perhaps eighty-mesh up to those just passing four-mesh. The maximum size depends upon the practice in the individual plant for the particular reclaim desired. The ideal is a uniformly-sized, fairly small particle, to present to the processing agents the maximum surface and a uniform depth to be reached. This ideal is difficult to reach in a commercial plant at a reasonable cost.

The sized scrap contains grit, sand, metal, etc., imbedded in the original rubber article during use. After sizing, loose iron particles of all sizes are removed by a magnetic separator, and ejected from the system. Some, of course, remain in the scrap particles and are carried on.

3. Devulcanization.

This is the heart of the process. At this point the reclaimer attempts to remove completely the elastic nature of the cured rubber scrap and regenerate or recover the original plastic characteristic of the uncured compound. Various theories have been advanced from time to time. Since sulphur combines with the rubber molecule in the usual cure, many attempts to remove sulphur during reclaiming have been made. The general belief today is that excess, "free" or uncombined sulphur can be and is removed by the alkali process, but that combined sulphur cannot be separated from the rubber. The cured rubber-sulphur compound seems to be broken up into smaller molecules, and by the additional action of softeners some measure of tackiness and plasticity is restored to the stock.

The actual process is carried out in steel vessels, jacketed for 150–200 psi. steam pressure, agitated, and from 3000 to 5000 gallons capacity. About 600 gallons of liquor, and 1500 gallons devulcanizer capacity, are used per ton of scrap charged, varying with the plant. The ground scrap is fed in together with a measured amount of 3.25 to 6.0 per cent caustic soda liquor and from 4 to 12 per cent softener on the dry scrap weight. Hydrated lime has occasionally been added to afford special characteristics to the final product. The softener used, in kind and amount, will vary with the reclaimer, the scrap in his formula and the quality of reclaim he desires to make. Materials like pine tar oil, solvent naphtha from coal tar distillates, petroleum fractions of all ranges, fatty acids have all been used at some time or other.

The whole charge is then well agitated and heated by full jacket steam. As a rule, fibre can no longer be found in the product after seven to eight hours at 200 psi., but further coating improves the smoothness and plasticity of product. During this step, all effort is made to get a time-temperature-pressure curve duplicating the standard or test run. Pressure controls on the jacket usually afford this.

At the specified time, the charge is dumped to a holding tank, using quick-opening, non-clogging discharge gates or valves, with the internal pressure to clear the line. By suitable means, such as a cyclone separator, the otherwise extremely foamy mass is dropped cleanly into the holding tank, which acts as a feed tank for the washing step.

As a rule, devulcanizing time varies inversely as the pressure. There have been reports of attempts to use pressures well over 200 psi., but it is felt that quality has not been satisfactory at these higher pressures. Mechanical difficulties are likely to increase sharply with pressure, and may have retarded this development

4. Washing.

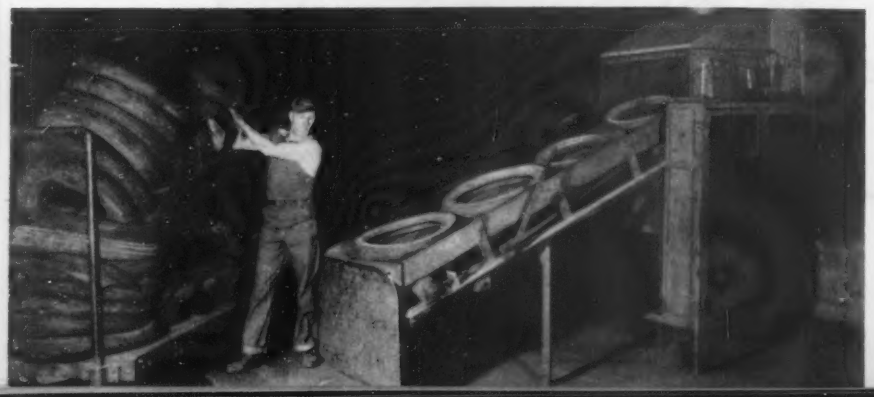
The slurry in the holding tank will usually run about one per cent in free alkali and/or alkali sulphide. It will contain about two and one-half pounds rubber solids per gallon. Since there is evident value in re-use of the liquor in the devulcanizer, it is separated from the rubber by filtration, straining or screening. Normally, the slurry can be pumped in centrifugal, impeller or diaphragm-type sludge pumps, to filters, strainers, or screens. Screens are usual and will run about 0.02 inches in opening size for the average grinding. Vibrating screens and rotary screens have been used. Inclined, fixed screens are frequently found.

The greater part of the liquid, containing one-third per cent solids, having been drained, wash water is applied to the solids moving down the screen. Both hot and cold water have been used, with wide variations in volume per unit of rubber. Possibly 600–1000 gallons per ton of dry product will state the limits ordinarily found. Here the reclaimer's practice is dictated by the type of scrap, particle size, alkali strength used and the specification for alkali in the product. This last is quite closely watched, since the rate of cure in the customer's hands is greatly affected by the alkali content of the reclaim.

5. Fines Recovery.

It is evident that washing on a screen with 0.02 inch openings will permit the passage into the effluent wash of at least a portion of the finer particles of rubber. Where the scraps contain large amounts of aged material, the tendency for shattering in grinding and excessive fines formation is great. This has allowed sometimes as much as 25 per cent of the devulcanized stock to pass into the effluent wash. While this condition may be eased somewhat by improved, more immediate separation at the grinding unit, it is seldom possible to reduce this loss through the washing screen to less than seven-eighths per cent of the output.

The modern reclaiming plant will therefore contain a very efficient recovery system, to allow good settling of the fines from the wash water and to provide filtra-



tion or other means to thicken the settled sludge enough to return it to the washed and dewatered stock. Dorr tanks and continuous filters are standard equipment, and cut the losses through the wash water to 0.5 per cent or less. They are of sufficient settling tank capacity to handle 800–1200 gallons of water and supply from five to eight square feet of filter surface, respectively, per ton of reclaim produced. Continuous, automatically controlled flow is the aim of all plants at this point.

6. Drying.

After washing, various means have been used to reduce the evaporation load on the dryers. These have been squeeze rolls, continuous centrifugal wringers and various other ingenious continuous presses. The average output of "dewatered" stock will run about 35 per cent water, 65 per cent dry reclaim. To this is added the recovered sludge from the fines recovery system, and the well-mixed material is then fed by conveyor and continuous feeders to the dryers.

Drying has been carried out in several types of equipment. The problem is removal of most of the water, at temperatures low enough to avoid burning, and at a rate which will prevent "case-hardening" of the particles. Rotary kiln dryers with oil- or gas-heated air at temperatures from 500–1000° F. have been in successful use for some time. Possibility of burning is great in such units, unless care is taken to maintain good feed control, and to regulate the temperature downward as the moisture content drops. A tendency toward formation of balls or lumps, very dry superficially, but wet internally, exists, especially if recovered sludge admixture is incomplete.

The industry for some time has worked away from this dryer, to the steam-heated, apron type used extensively in the chemical industry. This has the advantage of lower temperatures and reduced maintenance. There is no disturbance of the stock during drying on single aprons, and very little in the multiple-apron type, with ball formation eliminated as a result. Moistures are more readily controlled and are far more uniform.

Dried stock usually runs from four to eight per cent moisture, as bone-dry material will not process well in the massing and refining steps. To maintain uniform moistures, temperature and final stock moisture controllers are used. The finished dried stock is a crumbly, somewhat sticky mass, and must be stored in soapstone-dusted boxes to take it from the continuous units to the batch processes following.

7. Milling, Straining, Refining.

The dried stock, handled in tote-boxes, is first massed on apron mills. The crumbs, stuck together to a large extent but still not a tight homogeneous mass, are dumped onto smooth mill rolls, together with any pigments required to provide desired specific gravity and loading, and with the addition usually of softeners to lubricate and knit together the now reclaimed rubber.

The action is one of mastication, and has been carried out on 60 x 23 x 26 inches, or larger, double roll mills and in Banbury internal mixers. Other equipment providing a kneading action can be used, but usually does not perform economically.

The plastic sheets, still rough, are cut off the mill after about twenty minutes working, to be passed through large diameter, close-set two-roll refiners. Practice varies at this point, with gauge settings varying from 0.005 to 0.008 inches, depending upon the construction and condition of the refiners, and the product being run.

The insufficiency of the reclaiming process shows up here very clearly. Failure of the softener, alkali and heat to reach all parts of each particle, affected strongly by the lack of uniform particle size, allows to exist a core of less softened, less plastic scrap, which does not pass the bite of the refiner rolls with the plasticized stock. When, however, most of the soft material has literally been squeezed out, the harder, tougher "tailings" are caught and passed through. These are kept separate and returned to the apron or massing mill.

The soft material is sent to the strainer, a six-inch to ten-inch diameter screw machine operating like a meat grinder. This forces the plastic stock through a 20-mesh screen which catches the iron escaping the magnetic separator or picked up in the process, the bits of other metals, glass, stone, fibre, etc., not removed before, and the small very hard rubber particles carried through the refiner with the plastic stock. These objectionable items are scrapped out periodically.

The strained stock is finish-refined at 0.004 to 0.005 inches, or less if the refiner design permits, to form a smooth, soft sheet which is wound up on a drum. The one-inch thick slab is cut off as a finished reclaim, and after sampling and inspection for smoothness is soapstone dusted and stored on skids holding about a ton. Smaller volume, smaller particle size "tailings" are separated at the finish refiner. These can often be used in special rubber compounds. In absence of such demand, they are broken up and returned to the devulcanizer.

Finished reclaim is usually aged two to three weeks before use. Some forms are in use to permit storage up to or above six months. There is a slow stiffening or setting-up on storage, which is controlled by the amount and type of softener, the loading and the treatment during processing.

Tube Reclaims

Tube scrap is usually free of fibre, and carries less loading or pigmenting than does whole tire scrap. It is therefore typical, and forms the largest volume, of the direct steam processed scrap.

The preparation of the scrap is almost identical with that of whole tire, except that valves and patches must be removed by hand before the sizing operation. After sizing, the ground scrap is mixed, usually in a tumbler, concrete mixer, or similar device, with the desired softeners and pigments, and on occasion with alkali liquor — when the product specification requires an alkaline devulcanization. In any case, there is never enough liquid material added to cause flow of the stock. It retains its wetted solid particle nature.

Devulcanization is carried out in so-called "pan" devulcanizers. These are large, horizontal cylinders equipped to hold cars with racks of loosely covered pans or boxes of prepared scrap. With the devulcanizer sealed up, live steam is turned in on the pans to bring the vessel up to a pressure and for a time, varied from 80 to 200 psi., and from six to fifteen hours, to suit the requirements of the scrap and the product. Occasionally this "pan" process is modified to provide a jacketed, ribbon-type agitated vessel, with live steam applied inside to a wetted but still loose particle scrap.

The devulcanized stock dries on the release of the internal pressure, and is usually dumped and turned over to cool if it is necessary to store before milling.

Milling, refining and straining are similar to whole tire procedures. Occasionally, it is desirable to allow some ageing and then to reprocess the slabs through the milling and refining steps. This affords additional and more permanent plasticizing, where the customer's use demands a soft, dead stock.

Other Reclaims

Boot and shoe reclaims have been largely processed by the hot acid method. Ten per cent sulphuric acid has been used with several hours allowed for the cook. Acid processes are used only where the properties of an acid reclaim are necessary, as the evident installation and maintenance cost is excessive.

The mechanical process, using crackers, mills and refiners to break down the cured scrap and to incorporate high penetration softeners, produces at best a rough, coarse reclaim of low physical properties on the re-cure. However, the low cost of operation and plant goes a long way toward affording very low cost rubber for diluting or filling in low priced goods.

The volumes of the other reclaims do not compare with those of whole tire and tube reclaims by the alkali and the open steam processes.

Testing and Control

As mentioned above, the reclaimer must put out a product or products to meet fixed standards. He relies first upon scrap selection, next upon control of his plant operations as regards sizing, temperature, time, pressure, and tailings separation, and finally upon laboratory tests of his product.

The customer requires first controlled specific gravity, for control of his weight per volume or per piece. Next he wants constant cured properties, determined by the tensile strength and per cent elongation at break of the reclaim used. Hardness of the cured stock is important. Alkaline or acid reaction, affecting the rate of cure, must be determined, usually by titration of a water extract made by a standard routine. Extracts with acetone and chloroform, to show resin and softener content respectively, are sometimes demanded. Ash content and composition, together with moisture content, guide the customer in selection and the reclaimer in control of the commercial reclaims. Color specifications are relatively uncommon, but do exist, restricting the reclaimer in his scrap selection.

This industry has grown in the last forty years from a small beginning, where the product was termed "shoddy," to a factor in the rubber industry, turning out a line of goods found absolutely necessary to the production of numerous rubber articles. The tonnage has averaged about 200,000 long tons per year for the last two years. The product has held an important place in the rubber industry for some time, subject only to the supply and price of new, raw rubber. The recent world upheaval places still more responsibility on the reclaimer to utilize all types of scrap and to improve his product to fill the gaps formed by the restrictions on new rubber use combined with new applications of rubber goods.

GEARS MEAN PROGRESS

(*Continued from page 178*)

The materials of which modern gears are formed are as varied as their uses. The gear of steel and various steel alloys occurs in many different forms, some left soft, some toughened, some flame hardened, and some carburized and hardened. Cast iron, bronze and other metals are often employed. There is an increasing use of plastic and laminated substances for quiet-running, wear-resistant gears.

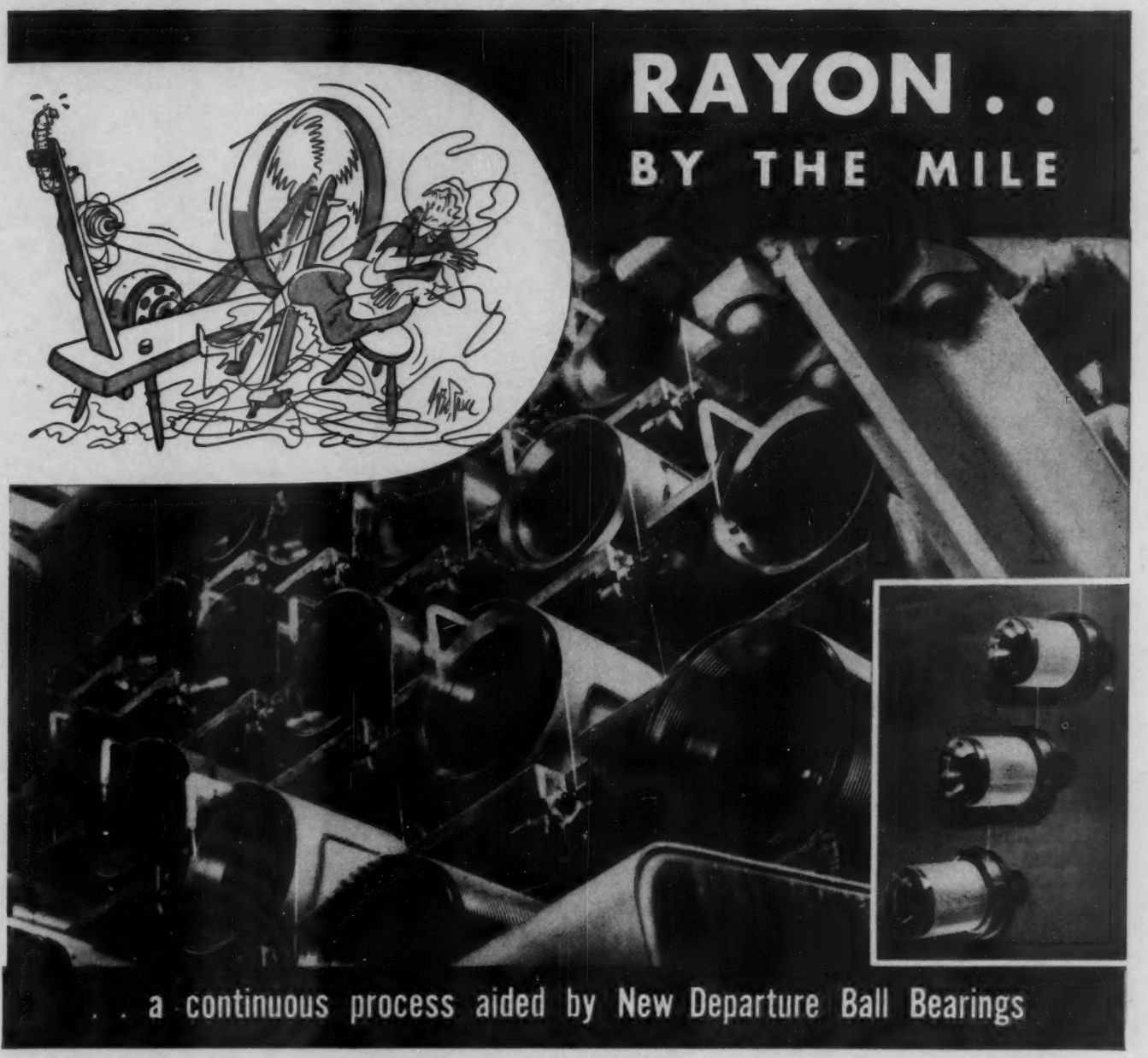
The statement that the degree of civilization can be shown by a study of the gearing is proven by observing the myriads of uses to which gears are now put, each use often requiring a specially designed type of gear. From the paper thin, one-eighth-inch gears in a watch to the twenty-foot, multi-ton giants in a ship, all play an important part in modern life.

WHAT'S AHEAD?

(*Continued from page 179*)

We have sketched over some of the things with which electrical men may be concerned in the future, emphasizing the technical aspects. These are and will remain basically important for every man associated with technical work. At the end of his first ten years after graduation, however, the electrical engineer usually finds himself responsible for more than technical matters. He will — often regretfully — be passing on fascinating details of technical analysis and development to his younger associates in order to make time for the greater responsibilities of planning and guiding their work and fitting it into that of other groups, watching their individual aptitudes, their progress, dropping suggestions and advice in a way best to promote individual effectiveness and growth, aiding his superiors by collecting and evaluating data on which they will base decisions, probably dealing in his special field with representatives of other organizations or customers, and in general be acquiring those responsibilities which mean tougher and less tangible problems where men often loom larger than materials. He is entering that domain of sophomore ambition, "administrative work," in greater or less degree. Here technical soundness is essential, creativeness is valuable, but progress depends even more on judgment that can weigh imponderables with nicety, on understanding humans as well as hysteresis, and on those qualities of character that make men productive.

NOTE: For those who may wish a more extended "backsight" of electrical engineering, the Fiftieth Anniversary number (May, 1934) of *Electrical Engineering*, the official monthly publication of the American Institute of Electrical Engineers (A.I.E.E.), is a treasure house of both technicalities and personalities, of science, and of the art and character that make science work. For obtaining the latest "present position," from which one who wishes may do a little foresighting of his own, the current issues of *Electrical Engineering*, the *Proceedings of the Institute of Radio Engineers* (I.R.E.), the *General Electric Review*, *Electronics* magazine, *Electrical Manufacturing* magazine, and the *Bell System Technical Journal* — to mention only a few — contain suggestive material which can be improved upon only by visits to research and development laboratories where men are doing the work on which the publications of the next few years and much of the commercial developments of the next decade will be based. Unfortunately, national defense makes most of these laboratories practically inaccessible at present.



● The lowly silk worm has become old-fashioned indeed. Now, from liquid Rayon, finished thread is manufactured and wound in one continuous process—ready for the textile mill.

But the 100,000 reels and spindles of this great plant could not operate continuously without the friction-reducing, wear-avoiding qualities of the New Departure self-enclosed and lubricated ball bearings at more than 300,000 points. In fact, they make such a project commercially possible—simplify design, accurately locate rotating parts, eliminate periodic oiling and definitely reduce costs.

New Departure Forged Steel Ball Bearings are literally the *life* of any machine. Nothing rolls like a ball.

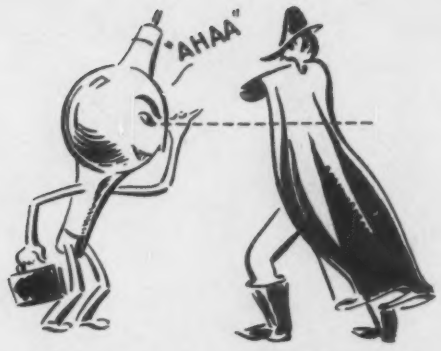
3052

This self-enclosed ball bearing is only one of numerous "new departures," the result of New Departure's well known creative engineering. Engineering students should be interested in booklet "Ideas by New Departure Engineers," for the practical use of the machine builder. New Departure, Division of General Motors, Bristol, Connecticut.

New Departure

BALL BEARINGS FOR DEFENSE

G-E Campus News



SUPER-PEEKSTER

EVEN when our defense "Sherlocks" can't, x-rays *can* "see right through" potential saboteurs and their hidden bits of destruction.

Without unwrapping or any dangerous tampering, suspicious packages may be inspected quickly and safely. Portable x-ray equipment is also used for fluoroscopic examination of overstuffed furniture, mattresses, or other articles in which questionable items might be hidden.

The x-ray has been instrumental in unearthing such things as a hypodermic needle and some narcotics cleverly hidden in a woman's handbag, a revolver baked in a loaf of bread, or hacksaw blades concealed in a cake of soap.

CURVES OF COLOR

THE most expert human eye can distinguish about 100,000 different colors, but that's practically color-blindness compared to the 2,000,000 that the G-E color analyzer can detect. The color analyzer can even measure your lady friend's blush, provided she holds it for two and a half minutes, and then, it will record it on paper for future reference!

The recording photoelectric spectrophotometer (that's the color analyzer's name) is only one of the things you can see in action in one of G.E's newest movies, "Curves of Color." This film, in full color, gives a 10-minute story of the world of color, telling why accurate color recognition is of such great importance to man and industry.

"Curves of Color" (16mm, sound) is purely educational and will gladly be lent to organized groups without any charge but the transportation costs. If you would like to show it at one of your dinners or club gatherings, just drop a line to Campus News, Dept. 318-6, General Electric Company, Schenectady, N. Y.

HOT DOGS AND COLD DIPS

THE strip mine of the Truax-Traer Coal Company in Fiatt, Illinois, hasn't actually been invaded by picnickers (yet) who want to cook hot dogs in the dipper of the big, 30-yard stripping shovel there, but it's an idea! Hot plates have been installed in the dipper, and Calrod heating elements have been put in the dipper handle.

The purpose of these heaters is not, however, to provide an extra service for possible picnickers, but to keep mud from freezing to the sides and bottom of the dipper. This used to reduce payload 50 per cent or more, and bonfires and a shutdown of 30 minutes to an hour were necessary to thaw out the frozen mass.

GENERAL ELECTRIC

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